

BACTERIOLOGICAL STUDIES OF THE
NEARSHORE AREAS OF
LAKE ONTARIO (1973-75),
DUFFIN'S CREEK (1974),
BAY OF QUINTE (1974), AND THE
ST. LAWRENCE RIVER (1975)

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Ministry
of the
Environment

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A BACTERIOLOGICAL STUDY OF
NEARSHORE AREAS OF LAKE ONTARIO,
1973 and 1975 SURVEYS.

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ABSTRACT

Water quality monitoring surveys were conducted in Lake Ontario during 1973 and 1975 to determine if Ministry of the Environment and International Joint Commission Objectives were being met.

The bacteriological data obtained indicated that much of the survey area had satisfactory water quality. There were, however, a number of areas adjacent to centres of population and/or tributary inputs that showed definite signs of fecal pollution and water quality degradation.

A BACTERIOLOGICAL STUDY OF NEARSHORE AREAS OF
LAKE ONTARIO, 1973 and 1975 SURVEYS.

INTRODUCTION

Surveys of the nearshore area of Lake Ontario were conducted in 1973 and 1975. The surveys were part of continuing Ministry of the Environment (MOE) programs to monitor Great Lakes Water Quality and assess compliance with current MOE Criteria and International Joint Commission (IJC) Objectives. The surveys were designed in order to determine the impact of municipal, industrial and tributary point source inputs and to assist in recommendations on and assess the effectiveness of abatement measures.

This report is concerned with the bacteriological water quality of Lake Ontario.

METHODS

Field Procedures

Bacteriological samples were taken at 72 stations in 1973 and 75 stations in 1975 (FIG.1).

Stations were sampled three times during each of the survey periods.

Three surveys were conducted in both 1973 and 1975:

- 1973
- (1) May 14 - 24, Port Credit to Port Hope
 - (2) July 7 - 15, Burlington to just west of Oshawa and the Port Hope-Cobourg area
 - (3) Aug. 13 - 20, Burlington to Cobourg
- 1975
- (1) July 23 - Aug 17, Niagara River to Oshawa
 - (2) Sept. 30 - Oct. 15, same area
 - (3) Oct 20 - Nov. 3, same area

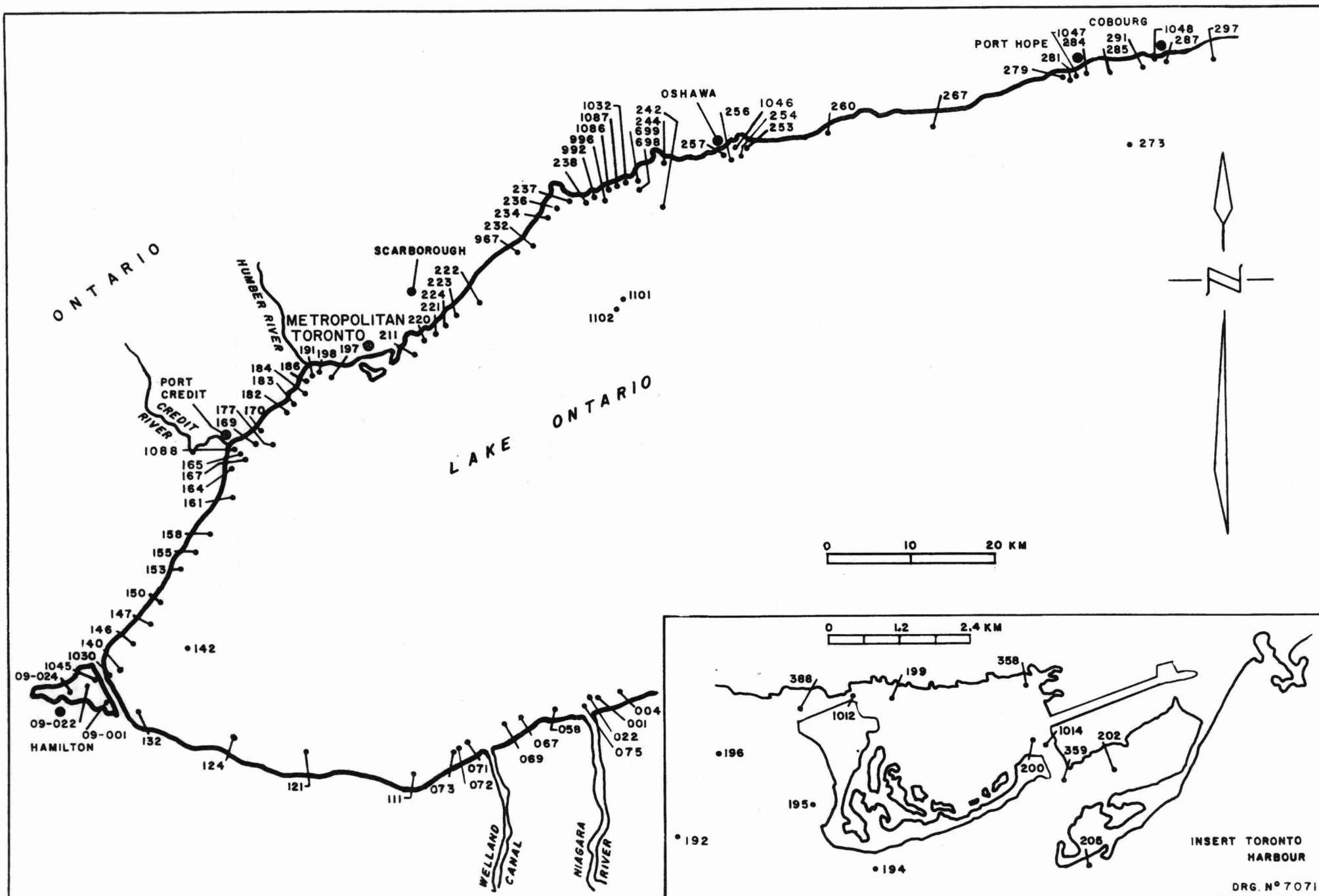


FIGURE 1 LAKE ONTARIO SURVEY AREA.

Surface samples were collected at approximately 1.5 meters below the surface of the lake while depth samples were taken at a depth of 10 meters. Samples were also collected at 3 meters from the bottom when the water depth was 17 meters or more. All samples in 1973 and depth samples in 1975 were taken in sterile 237 ml evacuated rubber syringes. In 1975 surface samples were collected in sterile glass 175 ml bottles. The samples were immediately put on ice and transported to the Toronto Laboratory for analysis.

Laboratory Procedures

All samples were analyzed for total coliforms (TC) fecal coliforms (FC) and fecal streptococci (FS). Analyses for these parameters were performed within twenty-four hours of sampling and counts were recorded as the number of organisms per 100 ml.

Membrane filtration methods were performed according to Standard Methods (1) using m-Endo Agar LES (Difco) for TC, MacConkey Membrane Broth (Oxoid) for FC and m-Enterococcus Agar (Difco) for FS.

In 1975 samples were also analyzed to determine levels of heterotrophic bacteria (HB) and Pseudomonas aeruginosa (P.aer). The HB analysis was performed within twelve hours of sampling and P.aer within twenty-four hours. On the third 1975 survey the HB analyses were not performed because the twelve hour limit could not be met.

HB analyses were performed using a spot plate technique (2,3) on a Foot and Taylor Agar (4) containing 100 ppm Actidione. Incubation was for seven days at 20°C and counts were recorded as the number of organisms per ml.

P. aer analysis was by the membrane filtration method of Levin and Cabelli (mPA) with incubation at 41.5°C for 48 hours (5).

Statistical Methods

Fluctuation in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean (GM). The large amounts of data generated from these surveys require that statistical methods be utilized to summarize the results concisely and to facilitate an unbiased interpretation.

Once the station group statistics had been obtained, an analyses of variance program (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analysis was first performed on all survey stations. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. At the same time as the ANOVA analyses were performed, the homogeneity of the variance was also checked using Bartlett's X^2 test of homogeneity. If either the F or X^2 values were significant, then stations were withdrawn until both were insignificant. The statistics were then repeated on the withdrawn stations until all stations had been properly grouped. The Student-t test (using GM and SE) was used to compare overlapping homogenous areas between each of the surveys.

Criteria

The criteria considered permissible for public surface water supplies when full treatment is supplied for the three sanitary indicator bacteria: total coliform, fecal coliforms, fecal streptococci and for heterotrophic bacteria are a maximum geometric mean of 5,000, 500, 50 and 100,000 per 100 ml respectively. The maximum permissible levels for private water supplies requiring chlorination only are 100, 10, 1 and 1,000 per 100 ml respectively, while that for waters requiring chlorination and filtration are 400, 40, 4 and 4,000 per 100 ml.

The Recreational Use Criteria states that: "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform and/or enterococcus geometric mean density exceeds 1,000, 100 and/or 20 per 100 ml respectively...". The geometric mean of the FS results is mainly used in a ratio with the corresponding FC geometric mean (FC:FS) to gain information on the source (Human or non-human) of pollution within areas adjacent to or at an input. If this ratio is greater than 4.0, the source of bacterial contamination is likely of human origin. If the ratio is less than 0.7 then the source is most likely non-human (6) It should be noted that this ratio is used to determine the source of pollution and not the safety of the water as animals are a potential source of organisms pathogenic to humans.

At present there is no criteria for P.aer. however its presence in water indicates recent fecal pollution (7).

Results and Discussion

Concentrations of sanitary indicator bacteria, in the area of Lake Ontario surveyed, were generally within MOE Criteria for

public surface water supplied and recreational use. Criteria for private water supplies, being more stringent, was exceeded more frequently. The areas in which criteria were exceeded were generally located near population centres and/or the mouths of tributaries.

1973

In May (Fig.2) there was good water quality in most of the area surveyed (10 TC, 1FC, & 1 FS/100). Exceptions were found in the area of Toronto Harbour (Group D:5390 TC & 69 FC/100 ml and Group C: 2560 TC/100 ml), Oshawa (STN. 1046: 480 TC & 21 FC/100 ml) and Port Hope (STN. 1047:1020 TC & 21 FC/100 ml).

The high FC:FS ratio at the entrance to the Port Hope and Oshawa harbours would indicate that the probable cause of increased bacterial levels is human fecal contamination possibly from improperly treated municipal wastes.

In Toronto Harbour, with the exception of the western end of the western channel (STN 388: FC:FS = 69), the FC:FS ratio is indicative of a combined input of human and non-human sources, probably due to the large number of inputs including storm sewers, outlets from industries and the Don River. There is no input at the western end of the western channel, however, the elevated FC levels may be due to inputs from the Bathurst Street storm sewer which is located further east in the channel.

The higher TC levels (204TC/100 ml) in the area west of Toronto Harbour may be due to the influence of the Credit and Humber Rivers and Toronto Harbour.

In July (Fig.3) the area from Burlington to just west of Oshawa had good water quality (36 TC, 1 FC & 1 FS/100 ml).

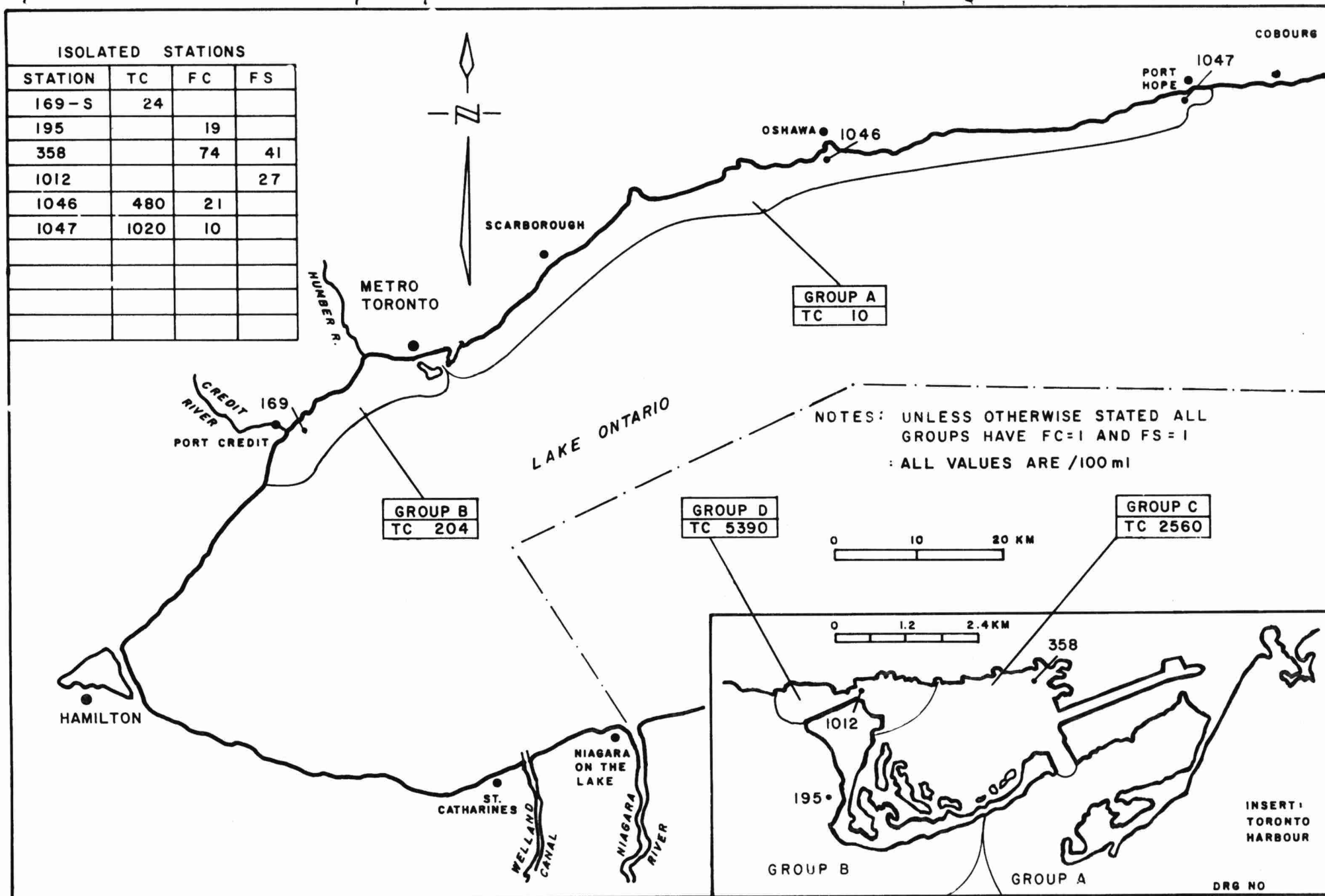


FIGURE 2 LAKE ONTARIO BACTERIOLOGICAL SURVEY, MAY 14-24, 1973.

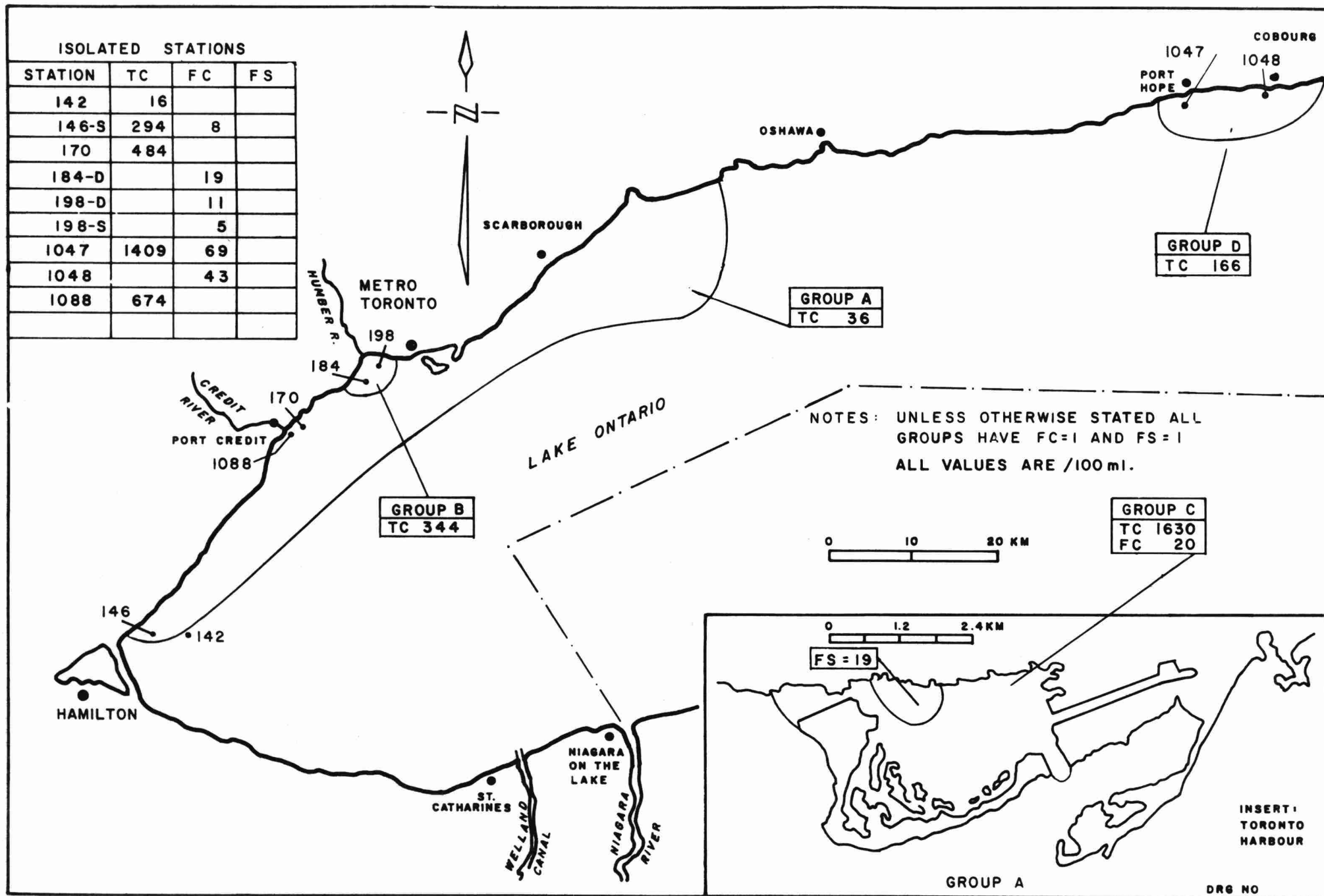


FIGURE 3 LAKE ONTARIO BACTERIOLOGICAL SURVEY, JULY 7-15, 1973.

These bacterial levels represented a small but significant increase from May in TC densities east of Toronto Harbour and a decrease west of Toronto Harbour. One reason for the fluctuation in bacterial levels may be the change in survey pattern. Stations were not surveyed along the entire shoreline east of Scarborough while additional stations were added west of Port Credit. The stations omitted and added during this survey were generally in areas of good water quality.

An area of Lake Ontario around the mouth of the Humber River (Group B:344TC/100 ml) and one area at the mouth of the Credit River (Stn. 1088:674TC/100 ml) had a significant increase in TC levels between the May and July surveys which would indicate that these two rivers are a source of pollution to the lake. There was some indication of human fecal pollution at the mouth of the Humber River as two locations had FC:FS ratios greater than four.

The TC densities in Toronto Harbour had decreased from May but with the exceptions of one area (Stn's 1012 & 199), the FC:FS ratio was much greater than four indicating a major contribution to bacterial levels from human fecal pollution. The increase in FC densities relative to FS levels could be indicative of cross connections between sanitary sewers and the storm sewers emptying into the harbour. The area surveyed around Port Hope and Cobourg differed from that surveyed in May and thus a direct statistical comparison is not valid. However, the data collected tends to indicate an increase in TC concentrations. The area adjacent to Port Hope Harbour (Stn.1047:1409 TC & 69 FC/100 ml) once again had TC levels exceeding MOE Recreational Use Criteria and an FC:FS ratio greater than four. An FC:FS ratio indicative of improperly treated human fecal waste was also apparent at

Cobourg (STN.1048).

In August (Fig.4) the entire area from Burlington to Cobourg was surveyed. The bacterial water quality in the Burlington to Oshawa area remained homogeneous (277 TC, 1FC and 1FS/100 ml) with a significant increase in TC levels from July. TC concentrations in Toronto Harbour had increased (5330 TC/100 ml) but only two points had a FC:FS ratio greater than 4 (Stn's 358 and 200). The remainder of the area had an intermediate ratio indicating mixed inputs (Stn's. 388, 199 & 359) or a ratio less than 0.7 indicating a non-human source of pollution (Stn's.1012 and 1014).

TC densities in the Port Hope and Cobourg area increased from the July levels. At Cobourg (Stn. 1048) the FC:FS ratio remained greater than four, however, at Port Hope where FC & FS concentrations had increased significantly (297FC & 129 FS/100) the ratio was intermediate indicating a combined input from human and non-human sources.

1975

In July - August (Fig.5) levels of sanitary indicator bacteria were generally within MOE Criteria except, as in 1973, exceptions were noted near populations centres and at the mouth of some tributaries.

The HB level over most of the area (8370 HB/ml) is higher than that found in the nearshore area of Lake Huron (8) which is indicative of the higher nutrient concentrations in Lake Ontario. The P. aer. density was low (2 P. aer./100 ml) over most of the survey area however, the presence of P. aer. does indicate that water quality is being effected by fecal material inputs.

Areas with bacterial densities elevated above the remaining nearshore areas included:

- (a) Oshawa (STN.1046:135TC/100 ml)
- (b) Toronto Harbour (STN. 358:156FC, 58 FS and 106 P.aer/100 ml)
and STN'S 1014, 359 & 202:59,000HB/ml)
- (c) Humber River (STN. 191 & 198:56,000 HB/ml
STN. 191:12 P.aer/100 ml, STN. 198:37 FC/100 ml
STN 186:31 FC/100 ml)
- (d) Credit River (STN. 1088:278 TC/100 ml and 152,000 HB/ml)
- (e) Hamilton Harbour (Group D:850 TC, 71 FC and 8 P. aer/100 ml)
- (f) Welland Canal (Group E:431 TC/100 ml)
- (g) Niagara River (STN:75 & 58: 58 FC/100 ml and STN. 75:1460
and 19 P. aer/100 ml)

Of the above locations the areas with particularly bad bacterial water quality (ie. elevated sanitary indicator bacterial levels, FC:FS ratio greater than four indicating improperly treated human fecal wastes and elevated P. aer. levels indicating recent fecal pollution) include the mouth of the Niagara River, Hamilton Harbour, the mouth of the Humber River, Toronto Harbour by the entrance to the Keating channel and in the area of Oshawa Harbour. These areas appear to be the most significant in terms of the poor quality of water entering the lake. High nutrient inputs would also appear to be present at the Credit and Humber rivers and Toronto Harbour.

In September - October (Fig.6) bacterial water quality was more homogeneous. In general TC concentrations tended to show a significant decrease from July in nearshore areas where they had been elevated and a slight but significant increase in areas that had had lower TC levels. HB showed a significant increase over the entire survey area (15,200/ml).

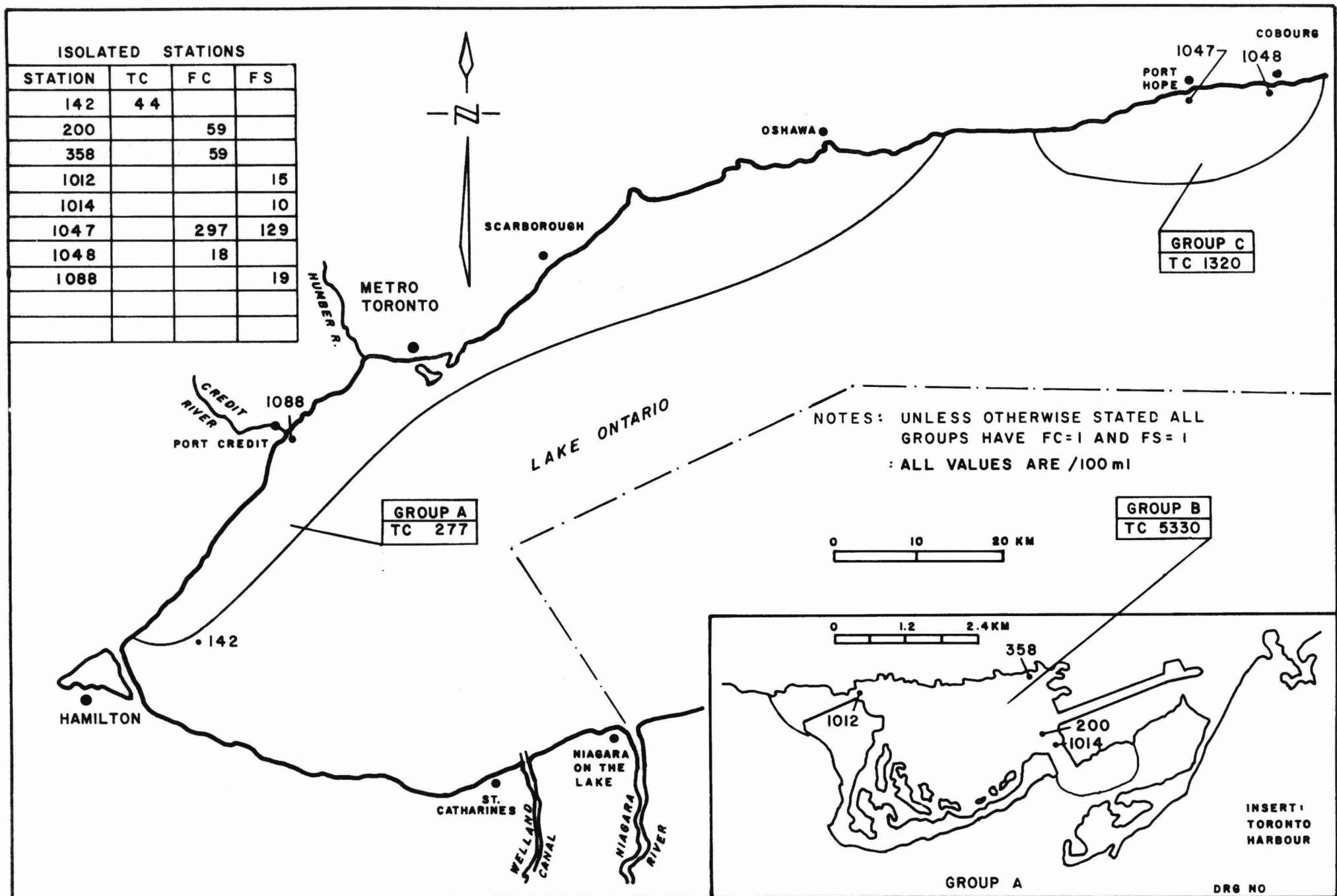


FIGURE 4 LAKE ONTARIO BACTERIOLOGICAL SURVEY, AUGUST 13-20, 1973.

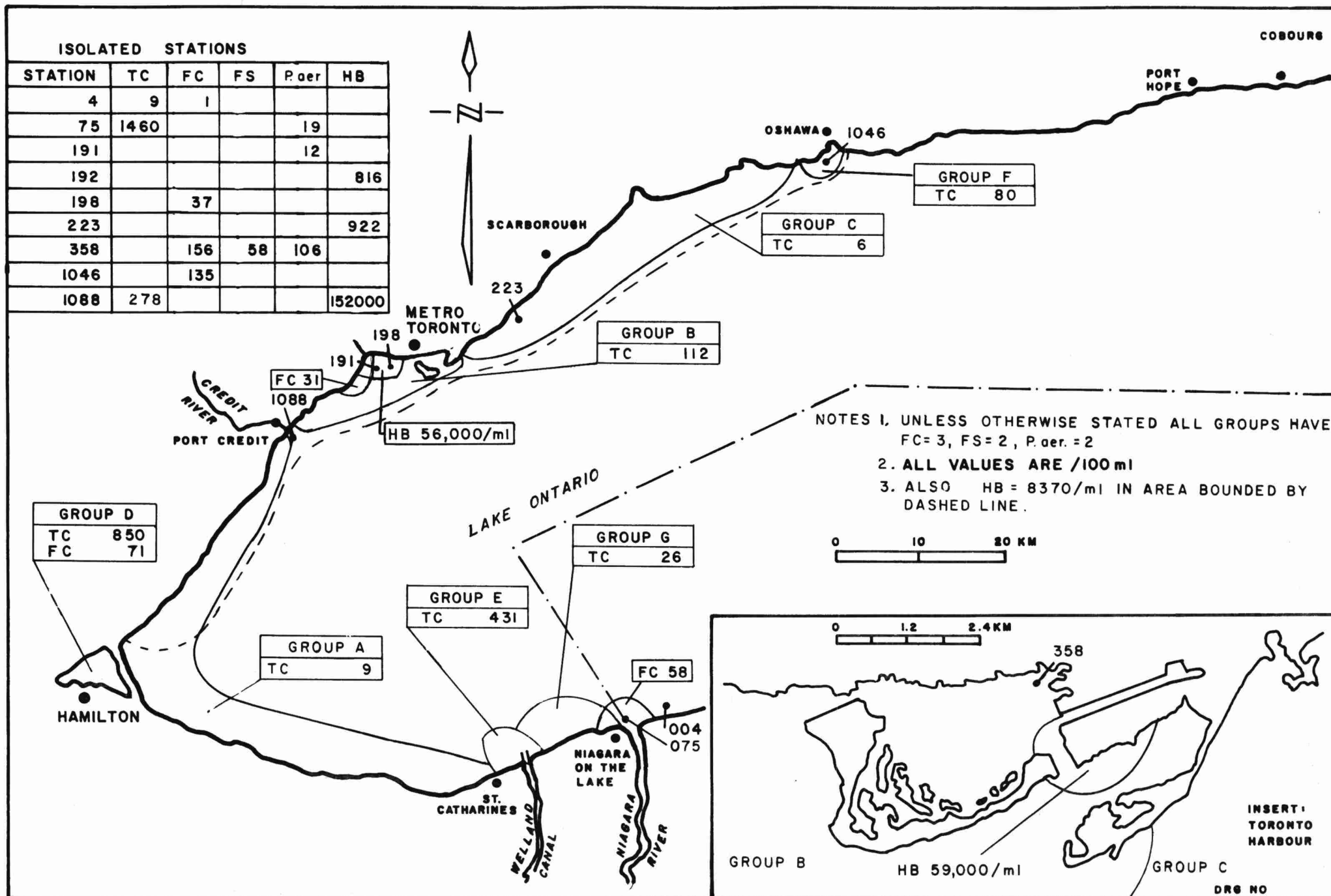


FIGURE 5 LAKE ONTARIO BACTERIOLOGICAL SURVEY, JULY 23 - AUG 17, 1975.

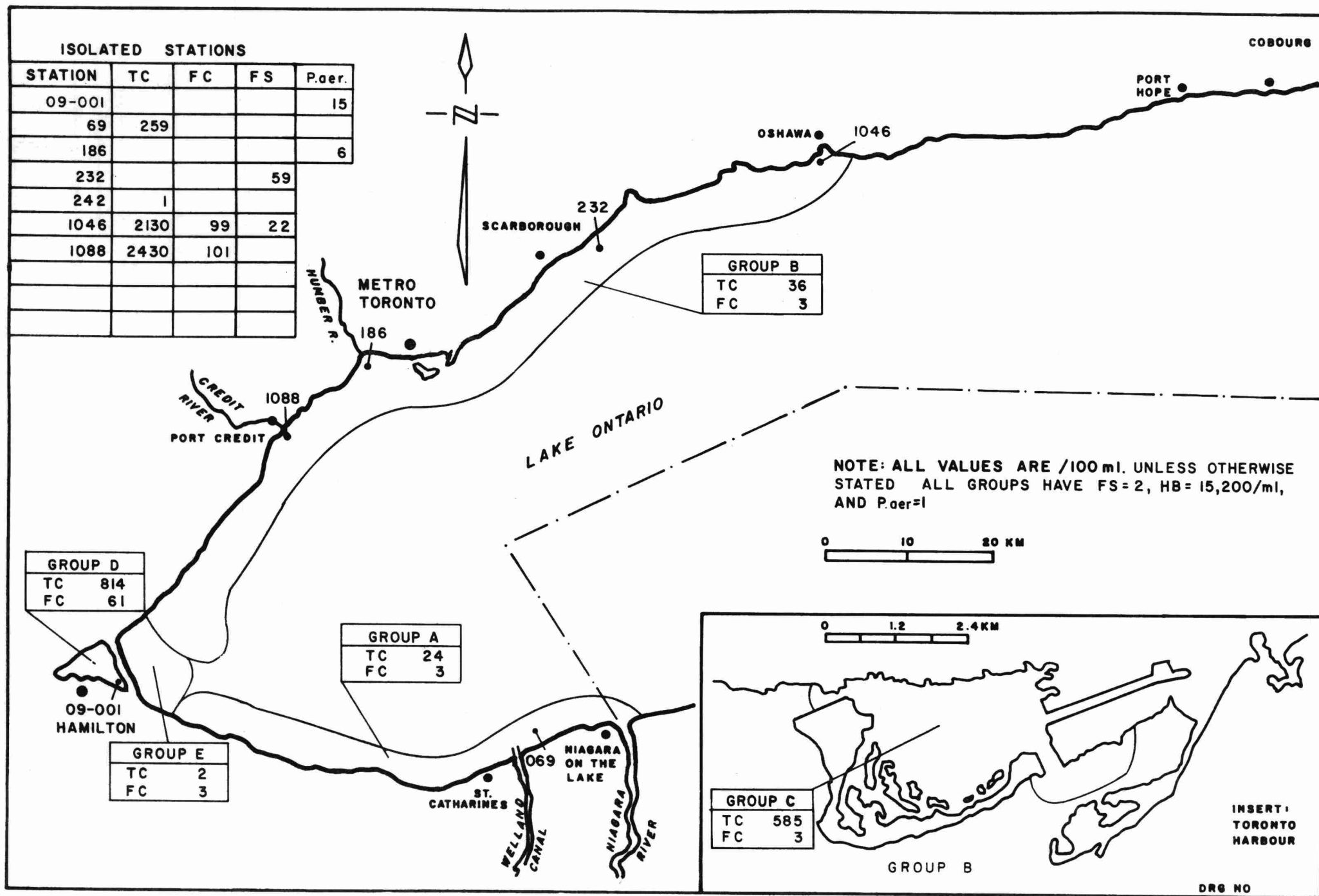


FIGURE 6 LAKE ONTARIO BACTERIOLOGICAL SURVEY, SEPT 30-OCT 15, 1975.

Areas with elevated bacterial levels were found in the same areas as in the previous survey;

- (a) Oshawa (2130 TC, 99FC & 22 FS/100 ml)
- (b) Toronto Harbour (58TC/100 ml)
- (c) Humber River (STN.186:6 P.aer/100 ml)
- (d) Credit River (STN.1088:2430 TC and 101 FC/100 ml)
- (e) Hamilton Harbour (Group D:814 TC/100 ml and STN.1:15 P.aer/100 ml)
- (f) Niagara River - Welland Canal area (STN. 69:259 TC/100 ml)

In the Oshawa and Credit River areas TC and FC densities reached or exceeded MOE Recreational Use Criteria and the FC:FS ratio exceeded 4 indicating that the source was probably human fecal wastes. One area in Hamilton Harbour, which showed no significant decrease in bacterial levels between July and September, had elevated levels of P. aer. The FC:FS ratio within the harbour was also greater than 4. The presence of P.aer. at the mouth of the Humber River would appear to indicate recent fecal pollution even though other bacterial concentrations were not significantly higher than surrounding waters.

In October - November (Fig.7) the bacterial water quality of the area was more heterogeneous, primarily because increases in TC levels in the vicinity of Oshawa, the Credit River and the Welland Canal - Niagara River area.

The Welland Canal - Niagara River area not only had raised TC concentrations (550 TC/100 ml) but the FC densities had increased as well (33 FC/100 ml). The FC:FS ratio at this point was much greater than four which is indicative of human fecal waste pollution. The presence of P. aer. (5/100 ml) in an area at the mouth of the Welland Canal would indicate that fecal pollution in this area was relatively recent.

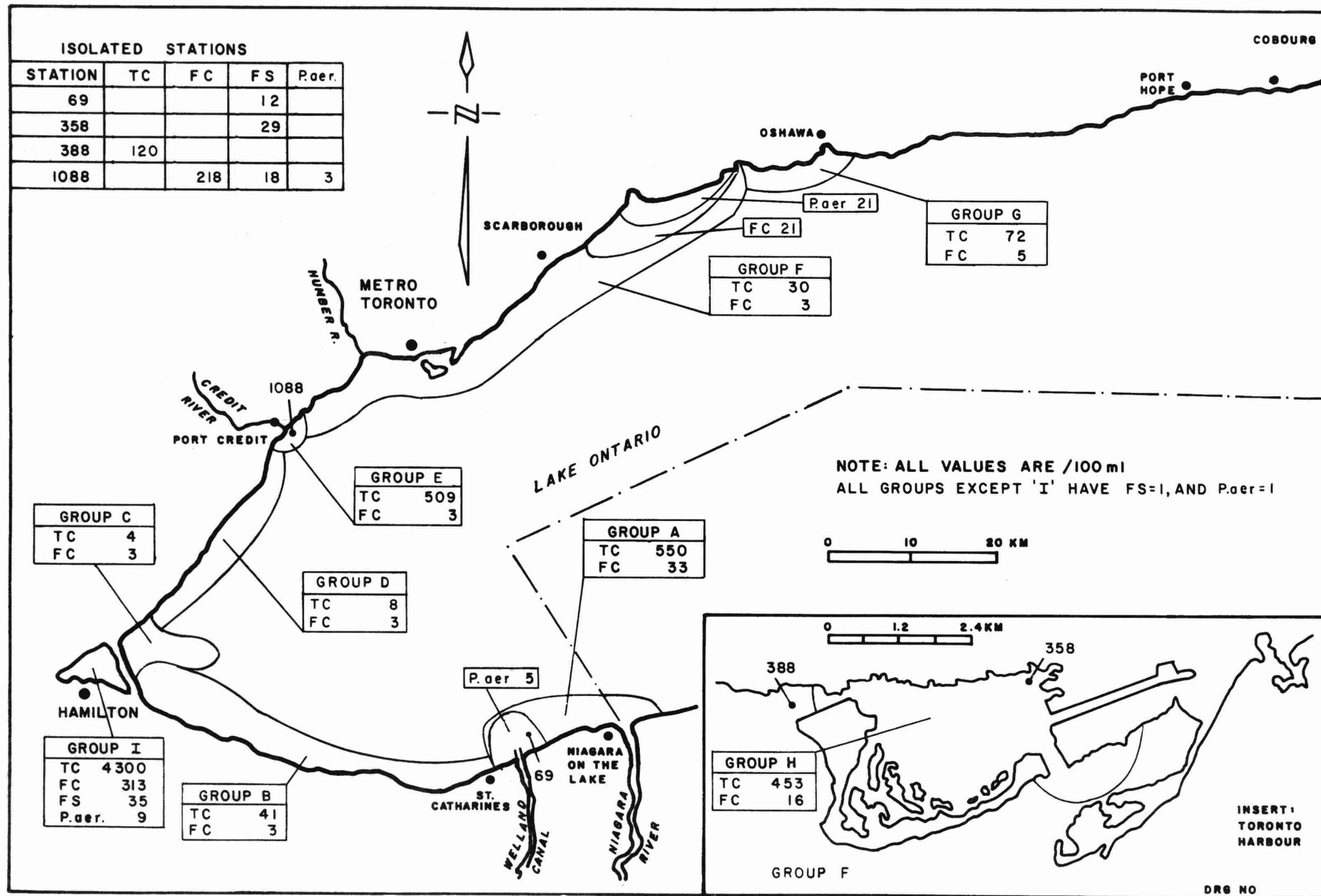


FIGURE 7 LAKE ONTARIO BACTERIOLOGICAL SURVEY, OCT. 20–NOV. 3, 1975.

The bacterial water quality in Hamilton Harbour (Group 1:4300 TC, 313 FC, 35 FS and 9 P. aer./100 ml) had deteriorated considerably from the previous two surveys. All levels of sanitary indicator bacteria were well in excess of MOE Recreational Use Criteria, the FC:FS ratio exceeded 4 and P. aer. were present.

The area around the mouth of the Credit River had elevated TC levels (Group E:509 TC/100 ml). One area right at the mouth of the river (STN. 1088:218 FC, 18 FS and 3 P. aer./100 ml) had excessive FC densities, a FC:FS ratio greater than 4 and P.aer. present indicating that pollution from human fecal material was entering the lake from the Credit River.

In Toronto Harbour there had been little change in water except for an increase in FC densities (16 FC/100 ml). The FC:FS ratio was now greater than 4, thus the probable source of pollution at this time was from human fecal wastes.

One area between Scarborough and Pickering which previously had background bacteriological levels had elevated FC (21 FC/100 ml) and P.aer. (21 P.aer./100 ml) indicating recent human fecal pollution. It is not possible to pinpoint the source due to the nature of the survey and the size of the area effected. There are a number of possible sources of pollution input in this area. There is a sewage treatment plant at the eastern end of the area and one at the western end and in addition three tributaries, Duffin's Creek, Frenchman's Bay and the Rouge River. The area in question has both municipal water intakes and recreational use areas, therefore, an attempt should be made to locate the source of the incoming pollution so that corrective action may be taken.

TC levels (72 TC/100 ml) similar to those found in July were evident in the Oshawa area.

Comparison of the 1973 and 1975 Surveys

It is not possible to determine if any trends may exist since not only did the survey areas differ but the last survey of 1973 and the first of 1975 are the only surveys with any overlap in time.

During the August 1973 survey the Lake Ontario nearshore waters had higher TC densities than during the July - August 1975 survey except at the mouth of the Credit River (STN. 1088). In contrast the FC concentrations were slightly, but significantly, higher in 1975 except at one location in Toronto Harbour (STN. 358). FS levels also tended to be higher in 1975 except at the mouth of the Credit River (STN. 1088) and two locations in Toronto Harbour (STN'S 1012 & 1014) which were higher in 1975.

The results may indicate that pollution by coliforms from non-fecal sources was less in 1975 than in 1973 but that there was a small increase in actual fecal pollution during the time of year in question (late July - August).

Summary

The bacteriological water quality of the nearshore area of Lake Ontario is reasonably good as determined by the 1973 and 1975 surveys. There are however exceptions located adjacent to areas of population or the mouths of some tributaries.

The areas of prime concern are the mouths of the Niagara River, Welland Canal, Credit River and Humber River, Hamilton and Toronto Harbour and areas adjacent to Oshawa, Port Hope and Cobourg. Attention should be paid to the area between Scarborough and Oshawa that had elevated P. aer. and FC densities during the final 1975 surveys.

It is necessary that consideration be given to some form of action to reduce pollution in the above areas not only to improve water quality in the specific areas but to protect the quality of the entire lake. In order to better establish the extent of the existing problems and to better determine the necessary remedial action more intensive surveys are required in the areas adjacent to the pollution sources.

Over the remainder of the lake the 1975 FC and FS concentrations would indicate the private water use should be accompanied by both chlorination and filtration. In addition, the HB levels determined in 1975 exceeded even the Public Surface Water Supplies Criteria. As new techniques have developed for the determination of this parameter since the original criteria were established it may be necessary to re-evaluate the levels suggested.

It is further evident from these studies that most of the nearshore waters, including some effected by various form of pollution, have sanitary indicator bacterial levels below current MOE and IJC Water Quality Criteria. Thus if the water quality is to be preserved more restrictive criteria must be applied.

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A BACTERIOLOGICAL STUDY OF THE DUFFIN'S CREEK AREA
OF LAKE ONTARIO, 1974

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ABSTRACT

A survey of the Duffin's Creek area of Lake Ontario was conducted in 1974 to monitor the water quality prior to the installation of a new trunk sewer system. The results showed that, at the time of the survey, the water quality was generally acceptable but that treatment facilities appeared to be operating at their capacity.

A BACTERIOLOGICAL STUDY OF THE DUFFIN'S
CREEK AREA OF LAKE ONTARIO

INTRODUCTION

An intensive survey of the Lake Ontario waterfront in the area of Duffin's Creek was conducted during the summer of 1974 as part of a Ministry of the Environment programme to monitor Great Lakes water quality. The survey was designed to determine the water quality with respect to M.O.E. Bacterial Criteria for various water uses and I.J.C. objectives and to supply data on the existing water quality prior to the installation of a new trunk sewer system in the Pickering area.

The survey area consisted of two distinct regions. The first extended from the mouth of Duffin Creek out to a point 709 m. offshore. The other was around the mouth of Carruther's Creek approximately 2 miles east of Duffin Creek. Carruther's Creek is unaffected by municipal or industrial inputs, therefore, a comparison can be made between the two locations in order to determine the effects of the existing inputs via Duffin Creek.

METHODS

1. Field Procedures

Bacteriological samples were collected at 6 stations at Duffin's Creek and 3 stations at Carruther's Creek. (FIG.1) The stations were sampled twice daily, three to five days a week (Monday to Friday) from July 15th to August 23, 1974 with the exception of the week of July 8 - 12 when no sampling was done, and the week of August 5 - 9 when sampling was carried out on August 7 only.

Samples were collected in sterile 6 oz. glass bottles at a depth of approximately 1 m. below the surface. The samples were immediately stored on ice and transported to the Toronto M.O.E. laboratory.

2. Laboratory Procedures

All samples were analyzed for total coliform (TC), fecal coliform (FC) and fecal streptococci (FS). Membrane filtration analyses were conducted according to Standard Methods (13th edition) using m-Endo Agar Les (Difco) for TC, MacConkey Membrane Broth (Oxoid) for FC and m-Enterococcus Agar (Difco) for FS. In addition, determinations of the densities of heterotrophic bacteria (HB) and Pseudomonas aeruginosa (P. aer.) were performed. Analysis of heterotrophs was done on a modified Foot & Taylor Agar (Appendix 1) using a spot plate technique (Bousfield, Smith & Trueman, 1974). Incubation was for seven days at 20°C and counts were recorded as the number of organisms per 1 ml. The P. aer. method utilized was the membrane filtration procedure suggested

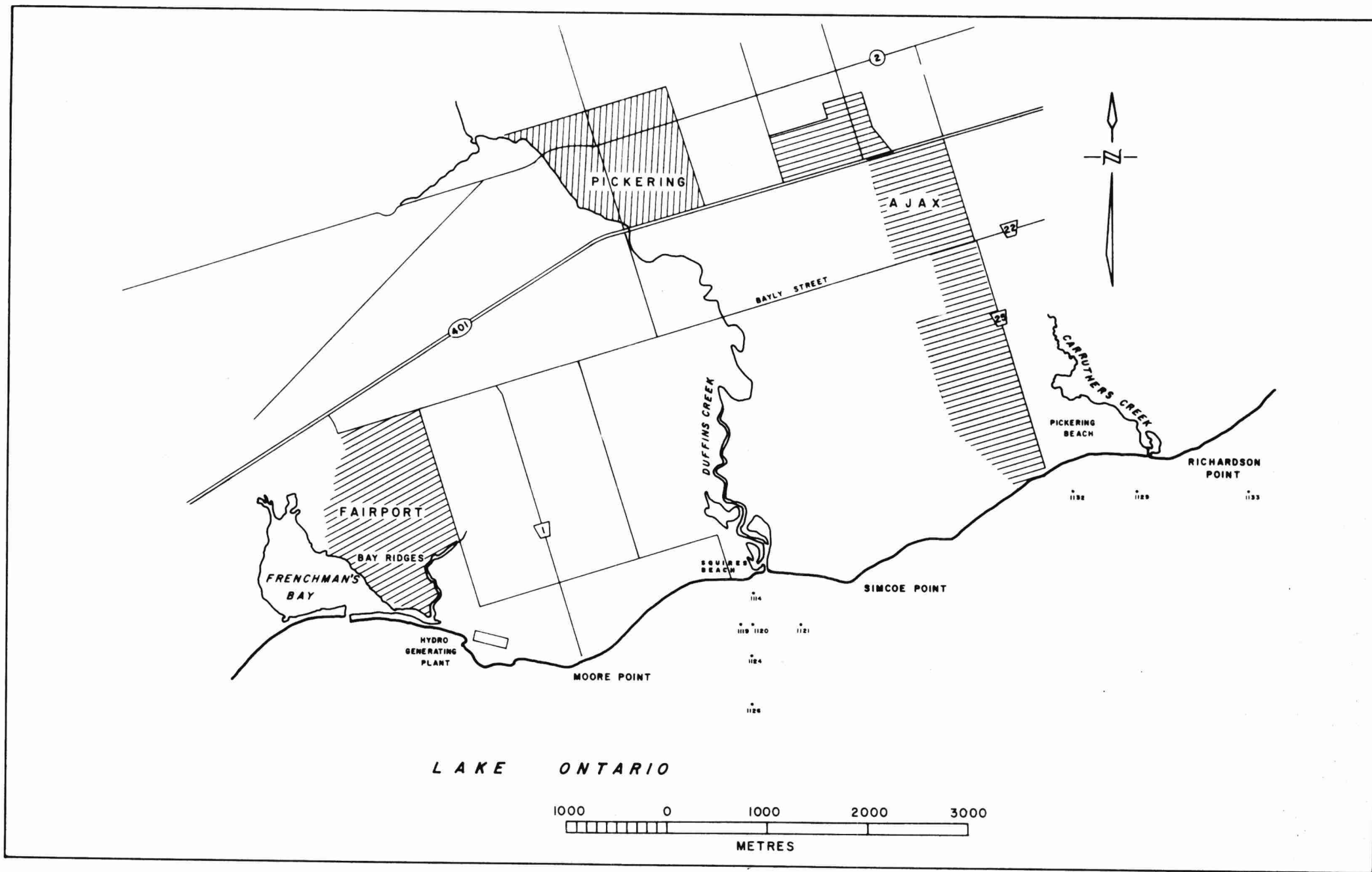


FIGURE 1 SAMPLING STATIONS NEAR DUFFINS CREEK AND CARRUTHERS CREEK, LAKE ONTARIO, 1974.

by Levin and Cabelli (mPA) using incubation at 41.5°C for 48 hours.

Analysis of all samples was carried out within 24 hours.

3. Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The large amounts of data generated from the Duffin Creek study required that statistical methods be used to summarize the results concisely and to facilitate an unbiased interpretation.

For this study, the two areas were assessed separately then compared. The daily results for each parameter were organized as replicate results for each station. The log geometric mean, the variance and the standard error (S.E.) were then calculated for each parameter at each station on a weekly basis.

Once the station group statistics had been obtained, an analysis of variance programme (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analysis was first performed on all survey stations. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. At the same time as the ANOVA analyses were performed, the homogeneity of the variances was also checked

using Bartlett's X^2 test of homogeneity. If either the F or X^2 was significant, indicating a non-similar grouping, stations that were judged to be significantly different, based on a statistical circumspection of the data, were tested and, if necessary, eliminated until both the F-ratio and X^2 were non-significant. The withdrawn stations were regrouped with respect to geographic proximity. The calculations on all groups were repeated using the ANOVA programme until each discrete group was homogeneous. The Student-t-test (using the log GM and SE) was used to compare overlapping homogeneous areas from one week to the next and also to compare parameter levels between the two survey areas.

Criteria

One of the prime reasons for inclusion of bacteriological parameters in water quality analysis is to indicate the presence of fecal contamination and thus the possible presence of pathogenic bacteria. Since the determination of specific pathogens in water is generally slow, laborious and uneconomical, specific groups of bacteria generally associated with fecal matter are used as indicators of fecal contamination.

Total Coliforms: This group of bacteria comprises species that are commonly associated with fecal matter (human and animal) and normal inhabitants of soil and vegetation.

Fecal Coliforms: These bacteria are mainly species associated with human and animal fecal matter and indicate a relatively recent pollution input.

Fecal Streptococci: This group of bacteria is largely associated with fecal pollution from animals and to a lesser extent man.

The geometric mean of the FS results is mainly used in a ratio

with the corresponding FC geometric mean (FC/FS) to gain information on the source (human or nonhuman) of pollution within areas adjacent to or at an input. If this ratio is greater than 4.0, the source of bacterial contamination is likely of human origin. If the ratio is less than 0.7 then the source is most likely nonhuman (Geldreich and Kenner, 1969). It should be noted that this ratio is used to determine the source and not the safety of the water, as animals are a potential source of organisms pathogenic to humans.

Pseudomonas aeruginosa: This bacterium is not yet an official parameter but it is a pathogen found in human fecal matter. Its presence in waters intended either for consumption or recreational use could constitute a major health hazard, as it is indicative of a local source of fecal pollution of serious concern to all users of those waters.

Heterotrophic Bacteria: This group of bacteria is indicative of general water quality and tends to reflect the level of nutrient enrichment of water.

The criteria considered permissible for public surface water supplies when full treatment is supplied for three sanitary indicator bacteria; total coliform, fecal coliform, fecal streptococcus and for heterotrophic bacteria are a maximum geometric mean of 5,000, 500, 50 and 100,000 per 100 ml respectively. The maximum permissible levels for private water supplies treated with chlorination only are 100, 10, 1 and 1000 per 100 ml respectively, while those for waters treated with chlorination and filtration are 400,

40, 4 and 4000 per 100 ml. The Recreational Use criteria states that: "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively".

Results & Discussion

The results of this intensive survey are summarized in Table I. During the first survey week (June 25-27), the (FIG 2), the geometric mean densities for most of the area around Duffin's Creek were 2 TC, 2 FC and L FS per 100 ml. These levels were well within all the M.O.E. water use criteria. The exception was the station located closest to the mouth of Duffin's Creek (station 1114) where bacterial levels for TC, FC and FS were 1150 TC, 282 FC and 26 FS per 100 ml. These levels exceeded the acceptable limits for private water supplies and recreational use. The fecal coliform to fecal streptococcus ratio of 10.8 at this station indicated that the bacteria was most likely of human origin. Pseudomonas aeruginosa was isolated once at a density of 286 P. aer. per 100 ml. Other samples taken during this period indicated that the mean density of P.aer. was relatively low.

Bacterial levels for all parameters around Carruther's Creek were found to be low. Tests of significance showed that the control area had significantly lower levels of TC, FC and FS than around the mouth of Duffin's Creek but was not significantly lower than the area beyond station 1114. This situation was generally characteristic of the relative levels throughout the survey.

Subsequent sampling periods showed a general pattern of bacterial fluctuations common to both sampling areas. A peak was reached over the July 1st long weekend (237 TC, 40 FC and 63 FS per 100 ml at Duffin's Creek) (Fig.3), than levels generally declined until July 26th when a low of 5 and 31 TC,

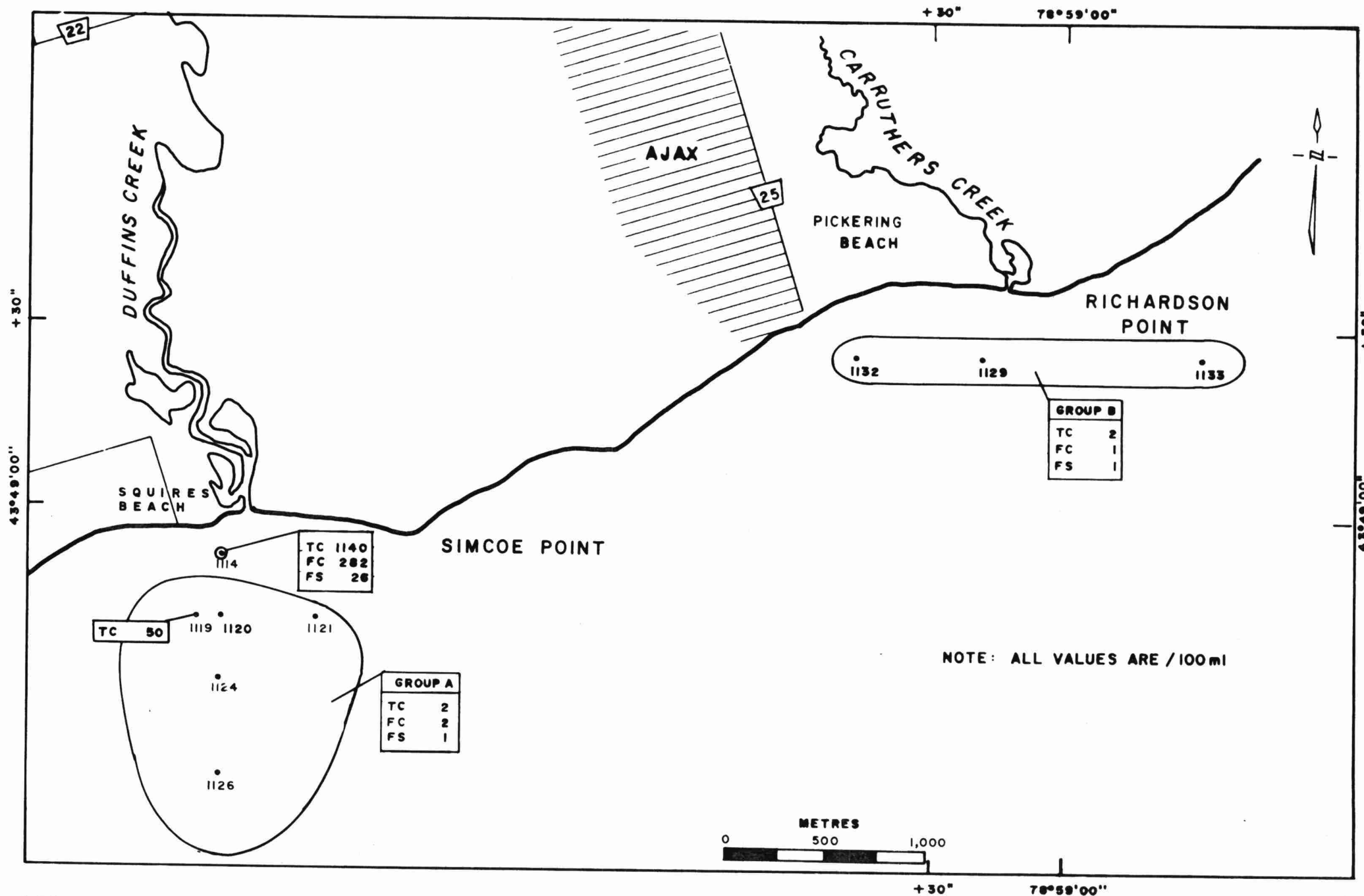


FIG. 2 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, JUNE 25-27, 1974.

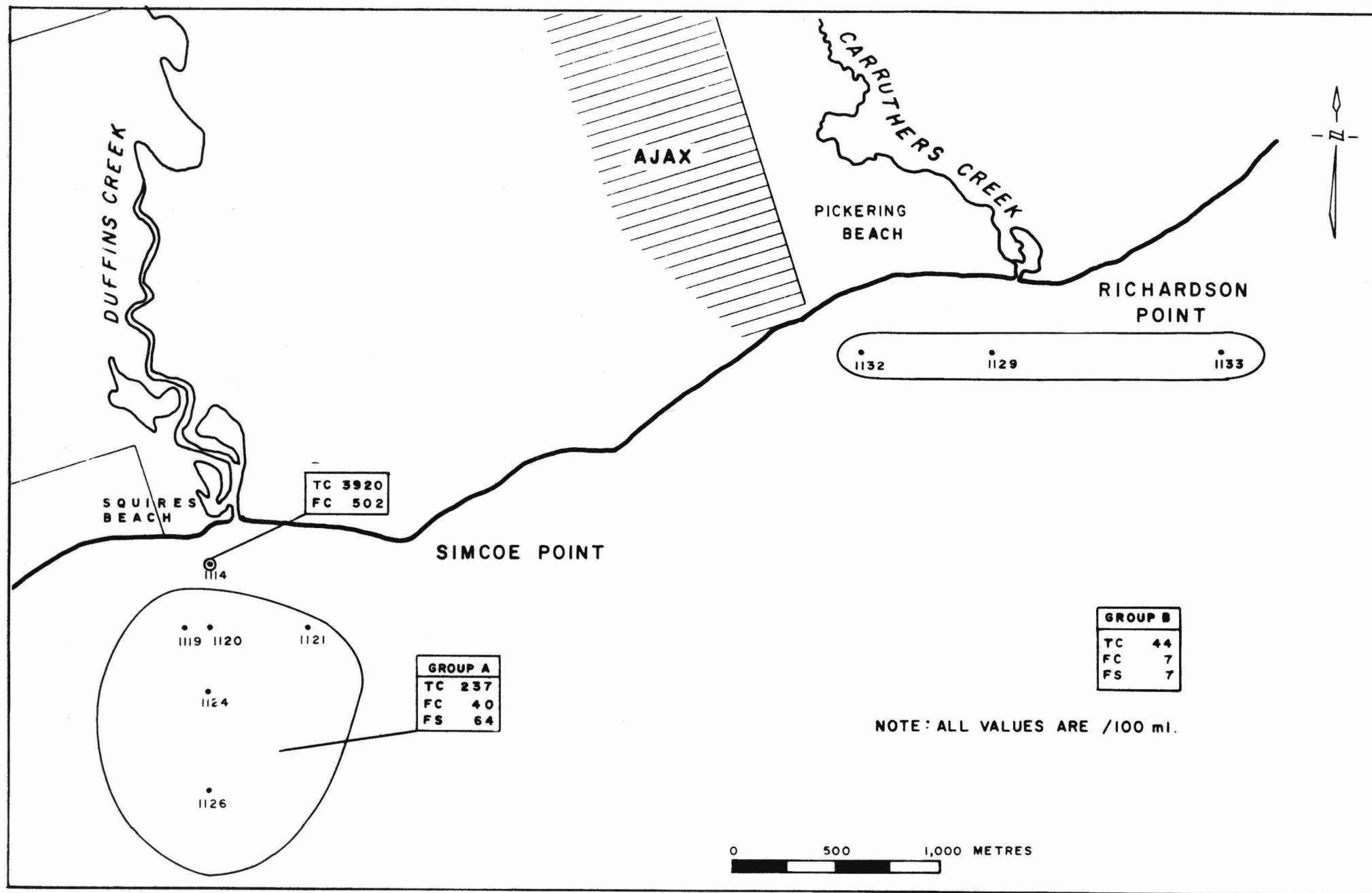


FIGURE 3 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, JULY 3-5, 1974.

TABLE I
BACTERIAL LEVELS IN LAKE ONTARIO
PARAMETER/100 ML

DATE	TC	FC	FS	P.aer	HB/ML
DUFFIN'S CREEK AREA					
June 25-27	2	2	1	1 (40)*	3080
July 3-5	237	40	64	4	8180
July 15-19	11 (111)	2	2 (7)	1	9350
July 22-26	5 (31)	2 (4)	4	1	8930
July 30-Aug.2	367	2 (11)	2	1	7347
Aug. 7	19	1	14	1	6374
Aug. 13-16	28 (100)	1 (5)	1	1	11,100
Aug. 19-23	2 (8)	1	2	1	2940

* figures in parentheses are GM of statistically different levels at station 1114.

CARRUTHER'S CREEK

June 25-27	2	1	1	1	-
July 3-5	44	7	7	1	3930
July 15-19	2	1	1	1	4790
July 22-26	5	1	4	1	4770
July 30-Aug.2	118	2	2	1	3040
Aug. 7 ⁺	13	1	31	1	7870
Aug. 13-16	9	1	1	1	3310
Aug. 19-23	3	1	1	1	1670

+ single sample

2 FC and 4 FS per 100 ml was reached (Fig. 4 & 5). During the period from July 30 to August 2 (Fig. 6), the TC and FC levels increased to 367 TC and 11 FC at Duffin's Creek. The long weekend peaks, however, did not violate any water quality criteria limits. Following the August holiday weekend, the densities again declined (Fig. 7 & 8) and by the final week of sampling (Aug. 19-23) were 8 TC, 1 FC and 2 FS per 100 ml.

An exception to the pattern was noted at the nearshore station (station 1114) where the TC and FC levels tended to be higher than either the control area or the remaining stations as a group. Sampling of three points located on Duffin's Creek during June, July and August of 1974 revealed generally high TC, FC and FS levels (Fig. 10 & Table II), usually above the recreational and private water supply criteria. This information would indicate that, under normal conditions, there is contamination originating in Duffin's Creek that adversely affects the water quality up to 112 m. from shore but that the effect on the surrounding area is limited by dilution. The FC to FS ratios in the affected area would indicate that the input is most likely of human origin. Although a dilution effect is evident, during periods of heavy input (eg. over a holiday weekend) the area influenced by the creek is considerably enlarged.

The total heterotroph densities remained fairly stable throughout the survey period, decreasing only during the final week of sampling. Heterotroph levels near Duffin Creek

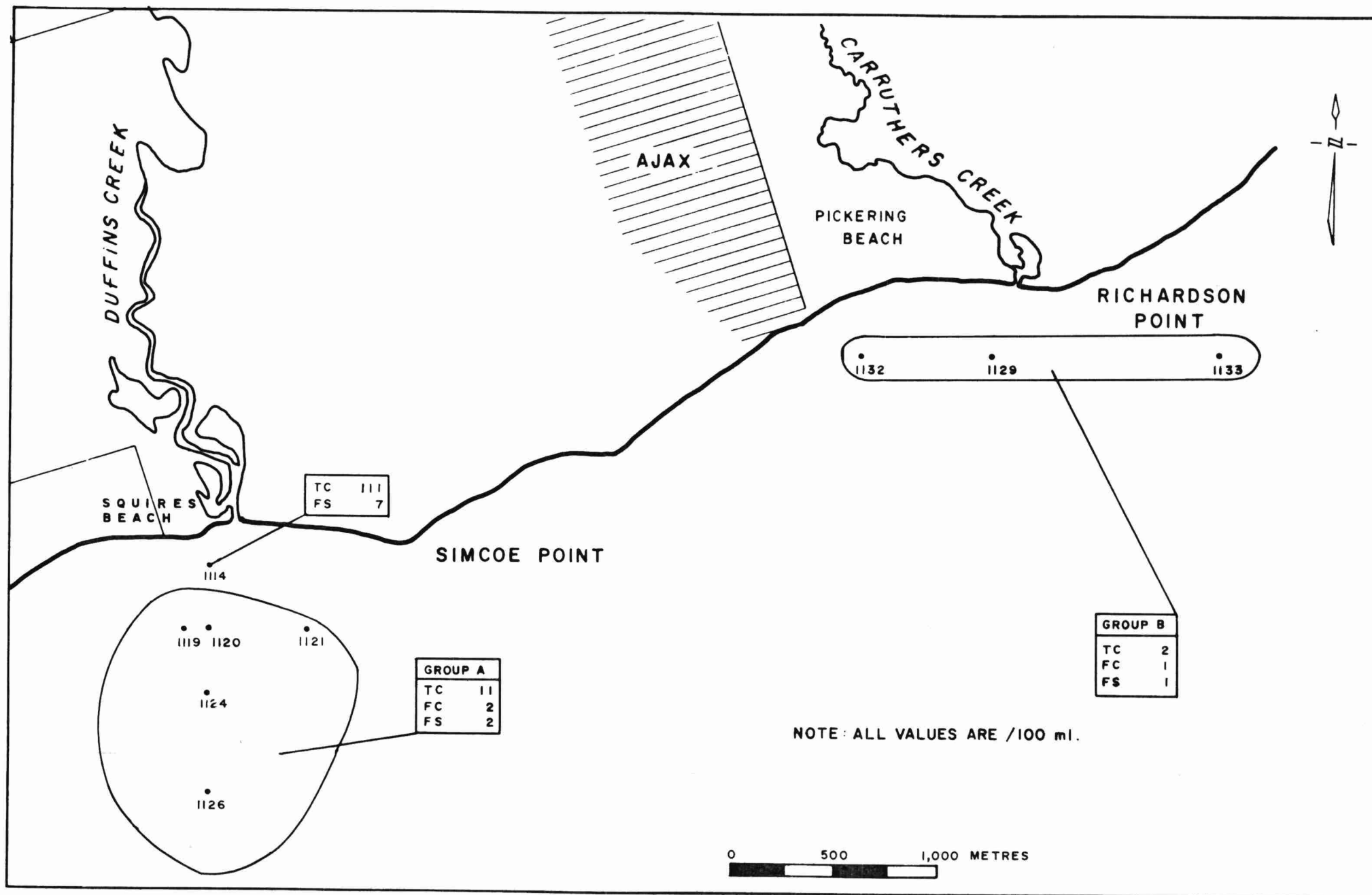


FIGURE 4 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, JULY 15-19, 1974.

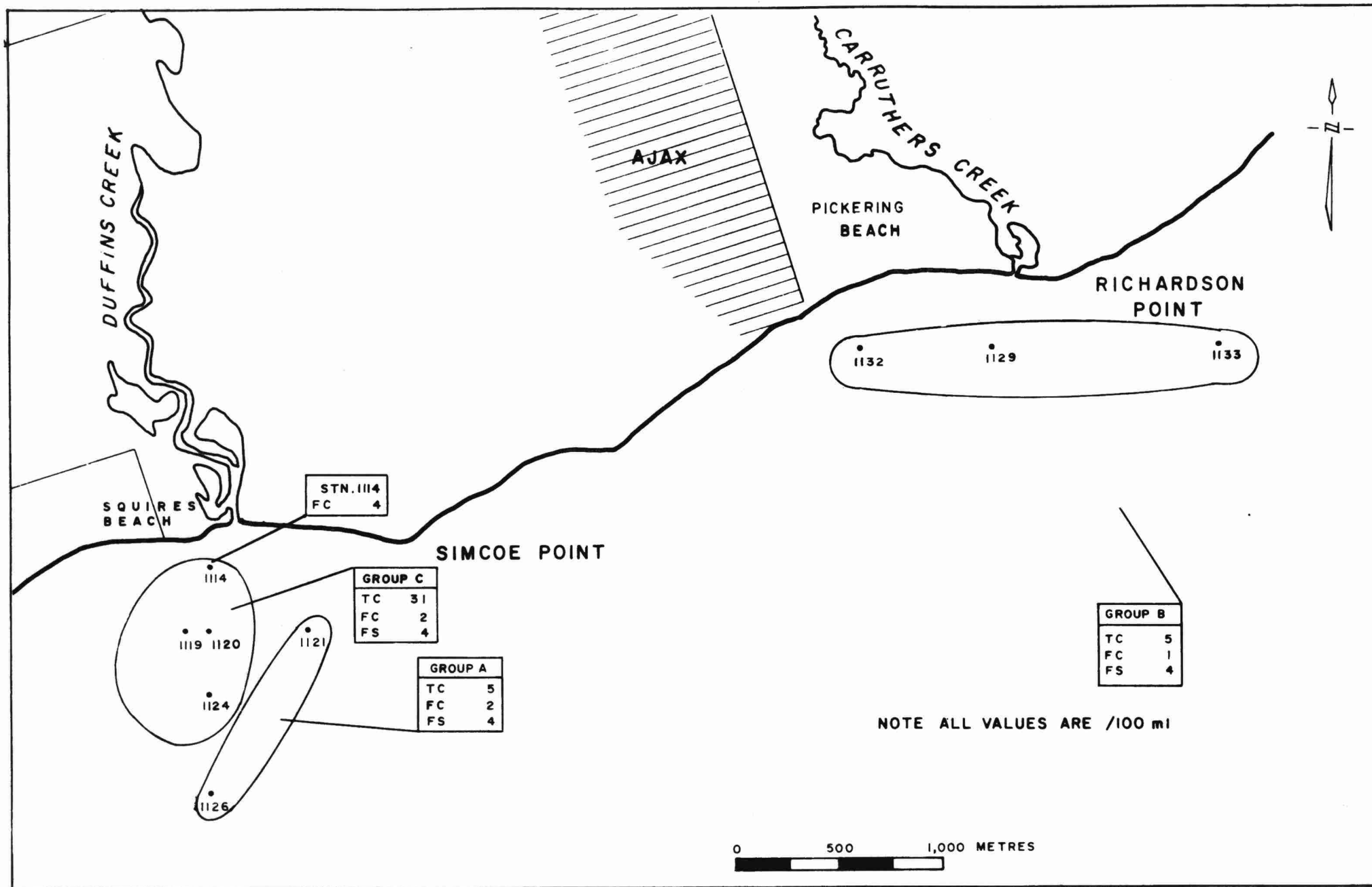


FIGURE 5 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, JULY 22-26, 1974.

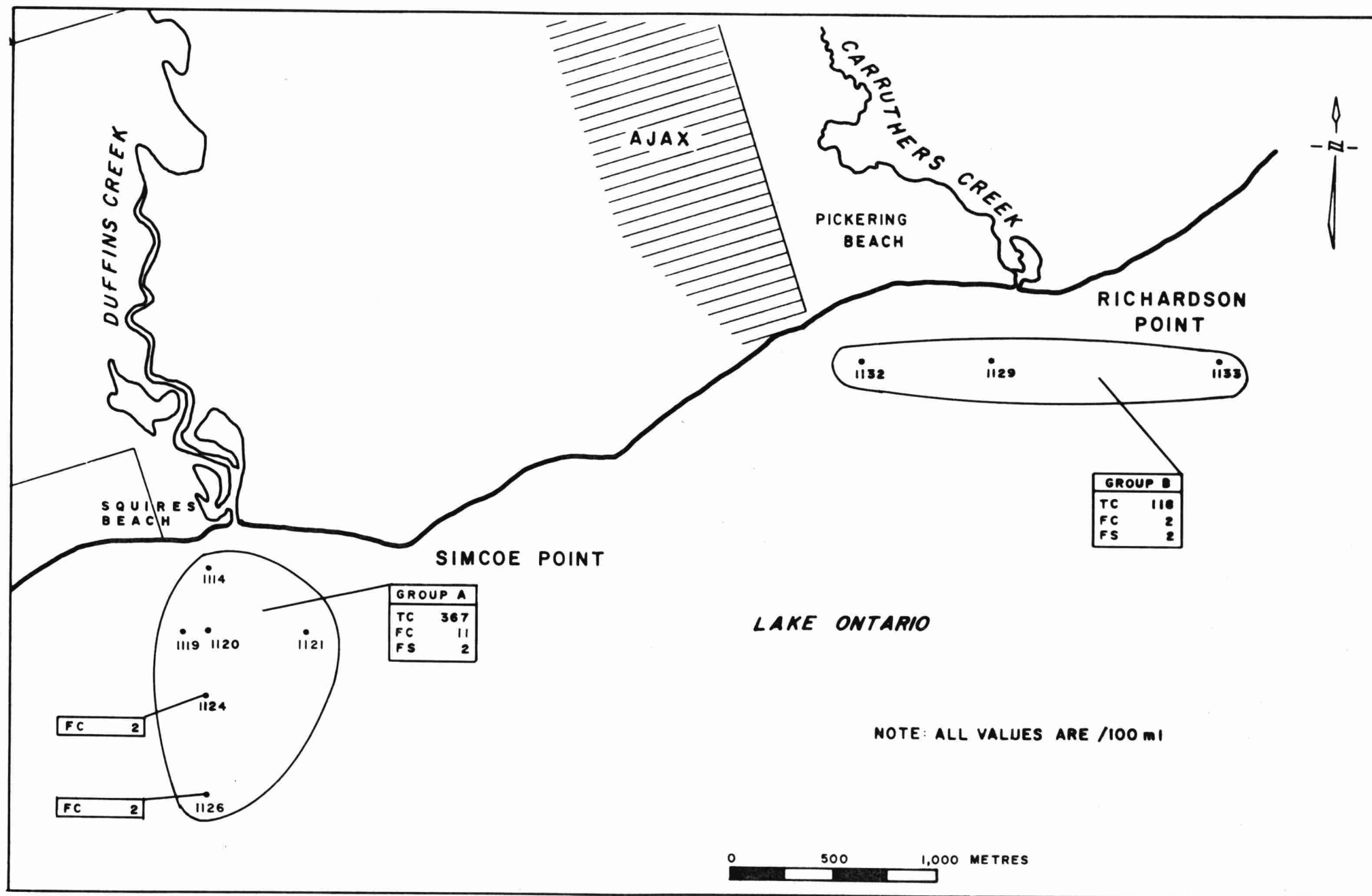


FIGURE 6 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, JULY 30-AUGUST 2, 1974.

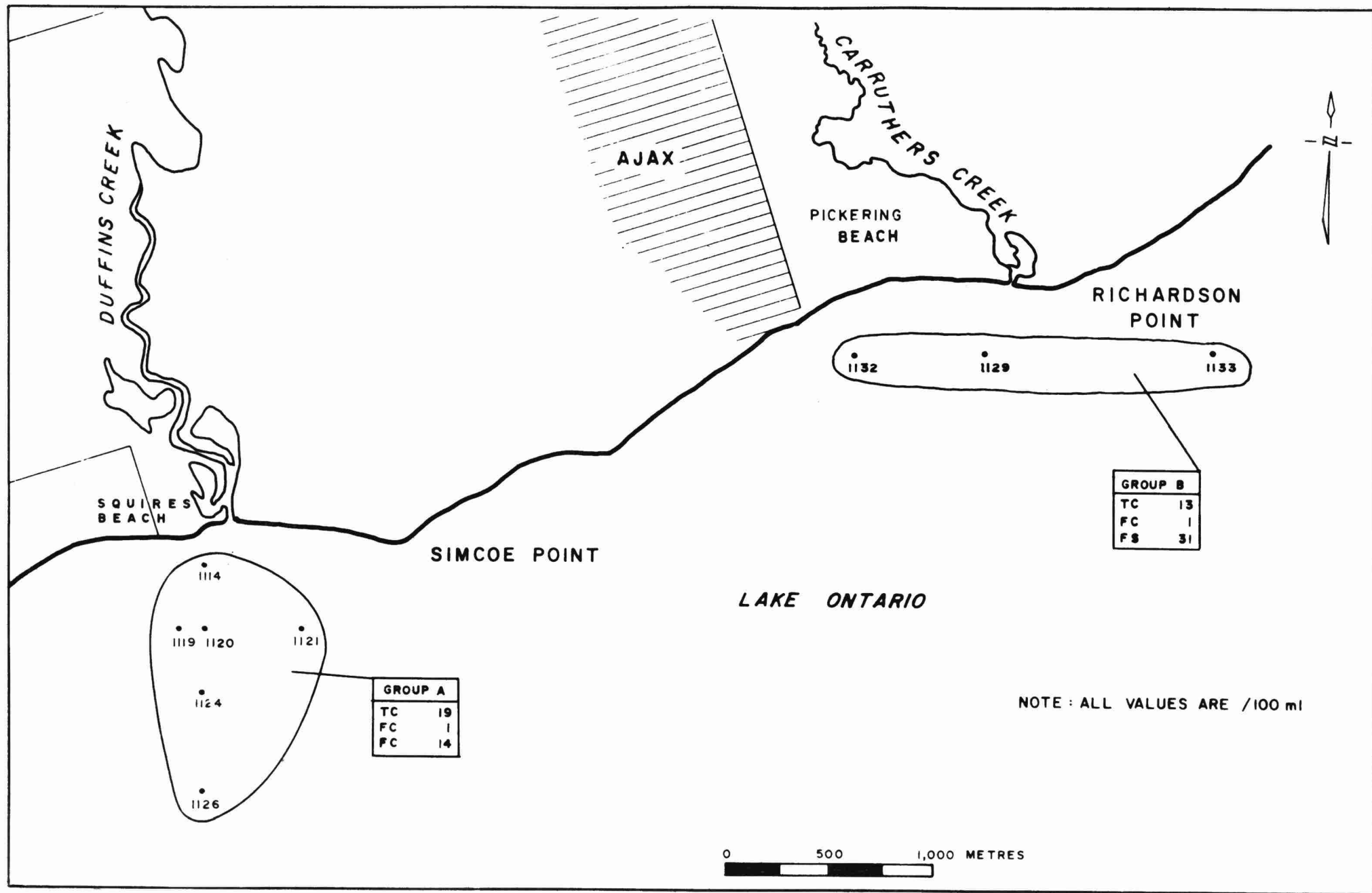


FIGURE 7 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, AUGUST 7, 1974.

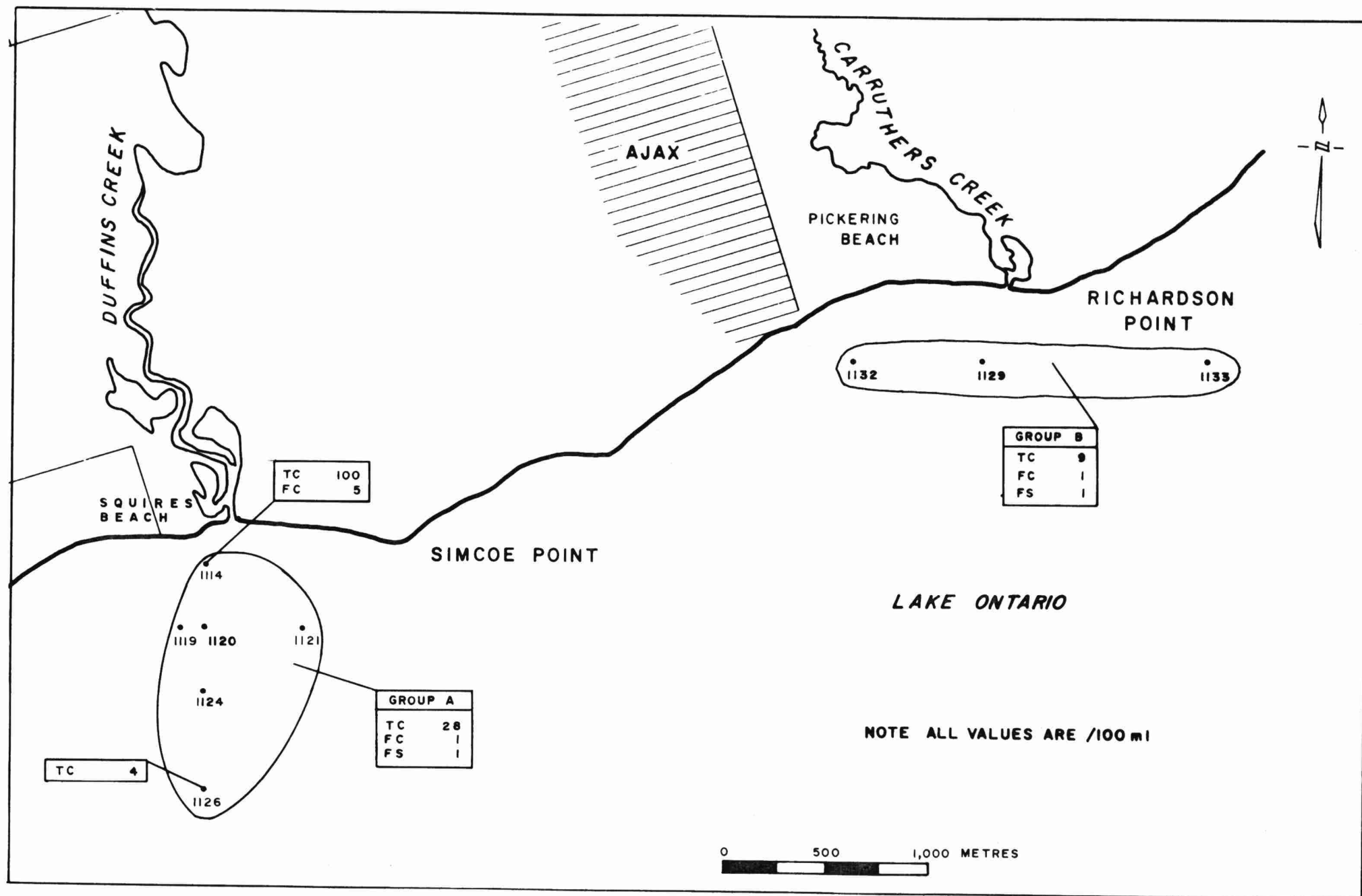


FIGURE 8 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, AUGUST 13-16, 1974.

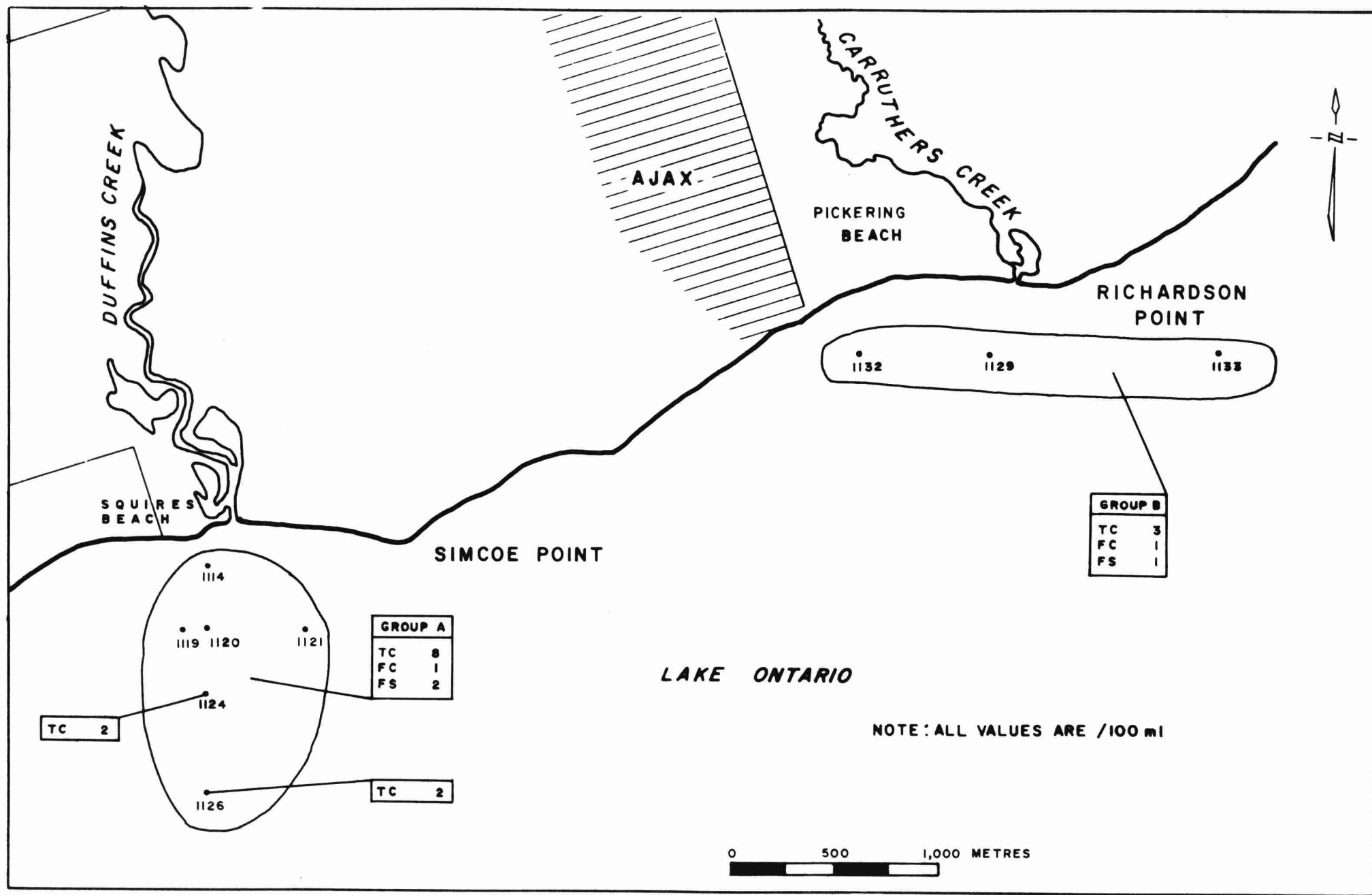


FIGURE 9 DISTRIBUTION OF BACTERIA, DUFFINS CREEK SURVEY, AUGUST 19-23, 1974.

TABLE II

BACTERIAL LEVELS IN DUFFIN'S CREEK

DUFFIN'S CREEK STN. LOCATION	PARAMETER PER 100 ML	June 10/74	July 17/74	Aug.19/74
Baseline Rd. (1 mi.W.of Ajax)	TC	7000	2800	2700
	FC	470	200	120
	FS	160	30	130
Downstream-Ajax STP (1 mi.)	TC	4300	66000	440
	FC	40	5000	70
	FS	< 10	< 1000	< 100
Hwy.2 (Pickering)	TC	1700	1500	800
	FC	90	80	80
	FS	10	100	90

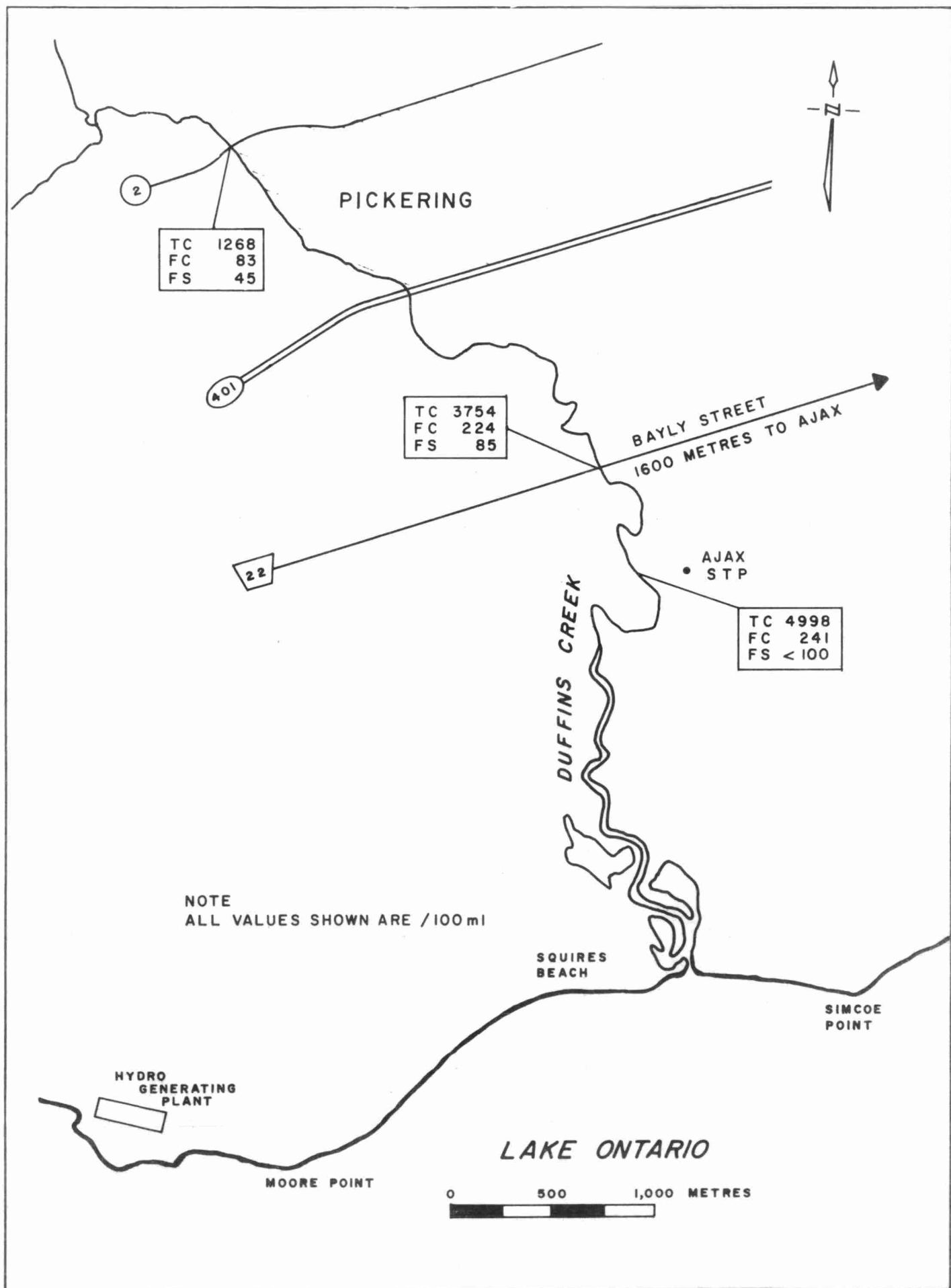


FIGURE 10 BACTERIAL LEVELS IN DUFFINS CREEK, 1974.

remained at about 7800/ml while those at Carruthers Creek were found to be significantly lower (3800/ml). This would indicate higher nutrient concentrations in the water at Duffin's Creek.

The level of Pseudomonads was generally low (not more than 4/100 ml.) with the exception of the previously mentioned sample taken at station 1114 during the first week. After the July holiday weekend, P.aer. concentrations at Duffin's Creek were significantly higher than at Carruthers Creek (Table 1). The presence of P. aer. is indicative of recent input of fecal material.

SUMMARY

The water quality of Duffin's Creek is generally acceptable. The rapid rise and fall of the bacterial densities throughout this study would indicate that the contamination of Duffin's Creek is of a sporadic nature. The timing of the peaks (i.e. after both holiday weekends) would indicate that although the existing facilities are adequate under normal conditions, they are operating at their limit and any further load (e.g. new development) would result in unsatisfactory input into Lake Ontario from Duffin's Creek. Expansion of treatment facilities would be recommended to keep pace with the growth of the area to prevent deterioration of the water quality in this area.

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APPENDIX

Foot and Taylor Agar (Modified)

Peptone	3.0 g
K_2HPO_4	0.2 g
$MgSO_2$	0.05 g
$FeCl_3$	trace
Soluble Casein	0.5 g
Agar	20 g
DH_2O	1000 ml
pH 7.2	Autoclave 15 min/15 psi

BACTERIOLOGICAL WATER QUALITY
OF THE BAY OF QUINTE - 1974

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ABSTRACT

In 1974, the Bay of Quinte was surveyed monthly from April to September to determine its bacteriological water quality and identify inputs.

The survey demonstrated that the Bay of Quinte was subject to both sanitary and organic nutrient pollution with water quality deteriorating during periods of heavy use (July and August). The major input sources appeared to be the population centres particularly Trenton and Picton.

INTRODUCTION

The prime purpose of the 1974 survey was to continue monitoring the water quality of this area to determine present water quality and better define input sources.

The Bay of Quinte is a Z-shaped bay, 87 square miles in area, on the northeastern shore of Lake Ontario. The greatest human development is along the north shore of the inner bay. The 1974 populations of the main centres along the shore of the Bay of Quinte were 35,125: Belleville, 14,481: Trenton, 1,833: Deseronto and 4,575: Picton (1). The Trent, Moira, Salmon and Napanee rivers all enter along the north shore of the inner bay. The middle bay stretches from the Napanee River to Picton while the outer bay stretches from Picton to Amherst Island. The watershed of the middle and outer bays is not extensive and the population is only about 1/5 of that along the north shore.

At the time of the survey, Trenton, Napanee and Picton had primary waste treatment plants with Belleville being the only municipality with secondary treatment, and no special measures had been taken for nutrient removal. Belleville and Deseronto obtained water from the bay for domestic and industrial use.

METHODS

1. Field Procedures

Bacteriological samples were collected at 24 stations (Figure 1) throughout the six 1974 survey periods from April to September inclusively. Each station was sampled three times during each survey period. Depth samples were taken in the outer bay (Stations 16 to 1103 inclusive) during the May and June survey periods. Surface samples were collected in sterile, autoclavable, polycarbonate, 250 ml bottles at a depth of approximately 1.5 meters below the surface, while depth samples were collected using sterile, 237 ml rubber air syringes. The samples were immediately iced and shipped to either a mobile laboratory located in Trenton or to the Toronto laboratory.

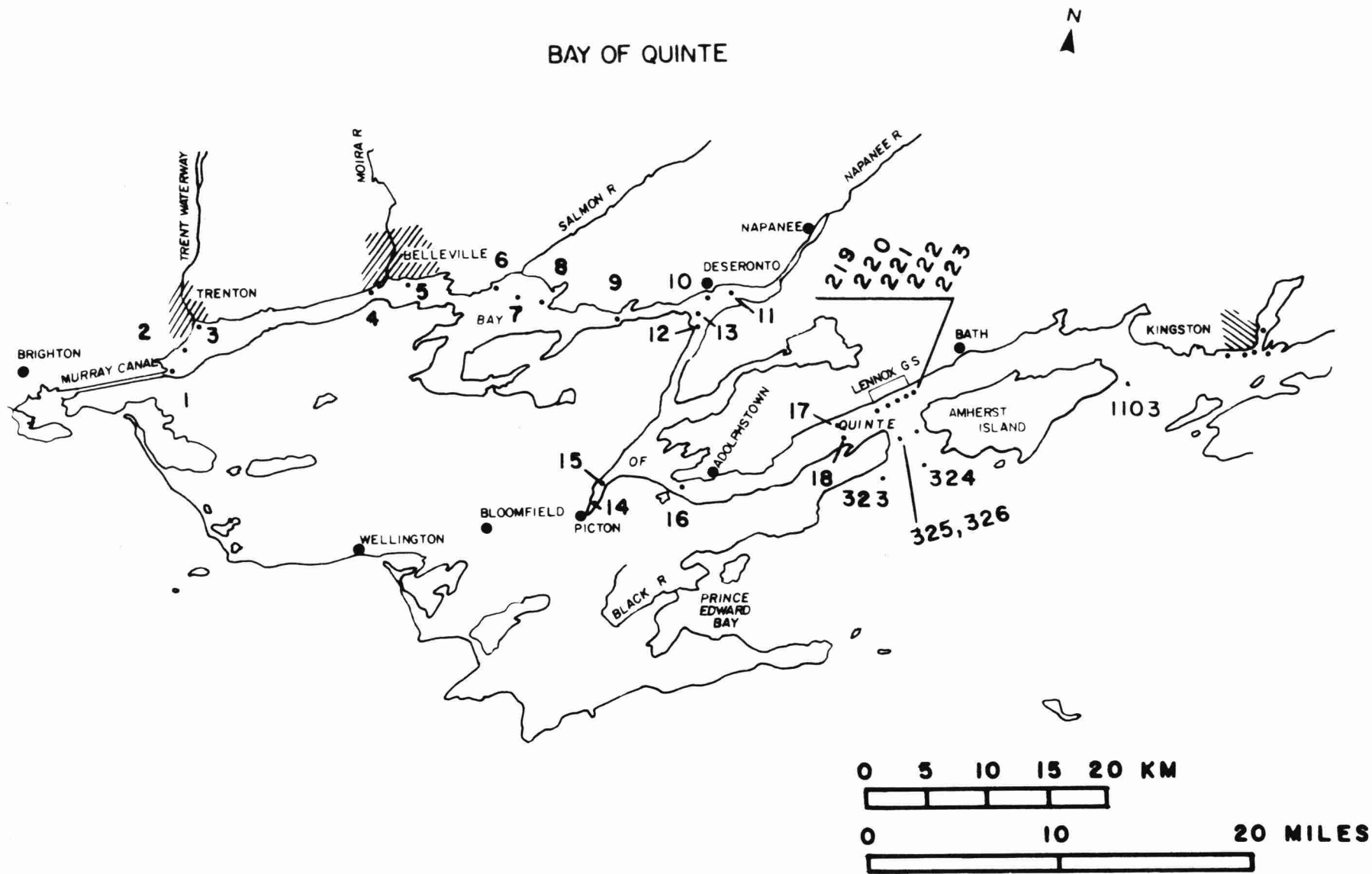


FIGURE 1 BAY OF QUINTE SURVEY AREA

2. Laboratory Procedures

All samples were analyzed using the membrane filtration technique for total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS) according to Standard Methods (13th edition) (2) using m-Endo Agar LES (Difco) for TC, MacConkey Membrane Broth (Oxoid) for FC and m-Enterococcus Agar (Difco) for FS. Analyses was conducted within 24 hours of sampling.

A heterotrophic bacterial count (HB) was conducted by the spot plate technique on modified Foot and Taylor agar (Appendix) during all but the July and August surveys. Analysis of HB was within 12 hours of sampling. The plates were incubated at 20°C for seven days. This parameter could not be performed during July and August because the 12 hour time limit (time allowed between sampling and analysis) was exceeded.

3. Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean (GM). The large amounts of data generated from these surveys required that statistical methods be utilized to summarize the results concisely to facilitate an unbiased interpretation.

Once the station group statistics had been obtained, an analyses of variance (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analyses were first performed on all survey stations. At the same time as the ANOVA analyses were performed, the homogeneity of the variances was also checked using Bartlett's χ^2 test of homogeneity. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. If either F or χ^2 values were

significant, then stations were withdrawn until both were non-significant. The statistics were then repeated on the withdrawn stations until all stations had been properly grouped. The Student-t test (using log GM and SE) was used to compare overlapping homogeneous areas between each of the 6 surveys.

CRITERIA

Belleville and Deseronto use water from the bay for domestic purposes, therefore, the Public Surface Water Supplies Criteria should be utilized to evaluate the water quality. The Recreational Use Criteria and the Private Water Supplies Criteria are also relevant since the bay has a cottage industry and is used extensively for varied recreational activities (3).

The criteria considered permissible for public surface water supplies when full treatment is supplied for the three sanitary indicator bacteria (TC, FC and FS) and HB are a maximum geometric mean of 5000, 500, to and 1000,000 per 100 ml respectively (4). The maximum permissible levels for private water supplies requiring chlorination only are 100, 10, 1 and 1,000 per 100 ml respectively, while that for waters requiring chlorination and filtration are 400, 40, 4 and 4,000 per 100 ml respectively (4).

The Recreational Use Criteria (4) states that: "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform and/or enterococcus geometric mean density exceeds 1,000, 100 and/or 20 per 100 ml respectively ... ". The geometric mean of the FS data is mainly used in a ratio with the corresponding FC geometric mean (FC/FS) to gain information on the source (human or non-human) of pollution within areas adjacent to or at an input. If this ratio exceeds 4.0, the source of bacterial contamination is likely to be human in origin. A ratio of less than 0.7 indicates non-human source of bacterial contamination" (5). It should be noted that this ratio only be used to determine the

type of pollution and not the safety of the water as animals are potential sources of organisms that are pathogenic to humans.

RESULTS AND DISCUSSION

In 1974, the Bay of Quinte had bacterial concentrations that were generally within MOE criteria for public surface water supplies and for recreational use. The Private Water Supplies Criteria, being more stringent, was exceeded more frequently. The areas in which the criteria were exceeded were located near municipalities and/or rivers where higher inputs were expected. The water quality was generally acceptable with respect to the sanitary indicator bacteria, but not heterotrophic bacterial levels.

Bacterial water quality in April (Figure 2) was good through most of the area, however, poor water quality was found in areas adjacent to Trenton (Station 3: 815 TC, 45 FC and 82 FS/100 ml) and to Picton (Station 14: 1415 TC, 153 FC and 10 FS/100 ml). At Picton, TC and FC levels exceeded MOE Recreational Use Criteria and the FC/FS ratio of 15 indicated the contamination was of human origin, probably from improperly treated fecal waste. At Trenton, the FC:FS ratio was 0.5 indicative of a non-human source of pollution.

With the exception of the outer bay, HB concentrations were high (17,900/ml) particularly near Belleville (35,400/ml) and Picton (42,500/ml). These levels are in excess of MOE criteria for public and private surface water supplies and are indicative of water enriched in organic nutrients.

In May (Figure 3), the concentrations of sanitary indicator bacteria tended to be significantly higher than in April though water quality remained relatively good through most of the area. Bacterial levels elevated above the remainder of the bay were again found at Trenton (Station 3: 2560 TC, 214 FC and 311 FS/100 ml) and Picton (Station 14: 2520 TC, 213 FC and 117 FS/100 ml). These levels all exceeded MOE Recreational Use Criteria as did TC densities at the mouth of the Napanee River (Station 11: 1500/100 ml).

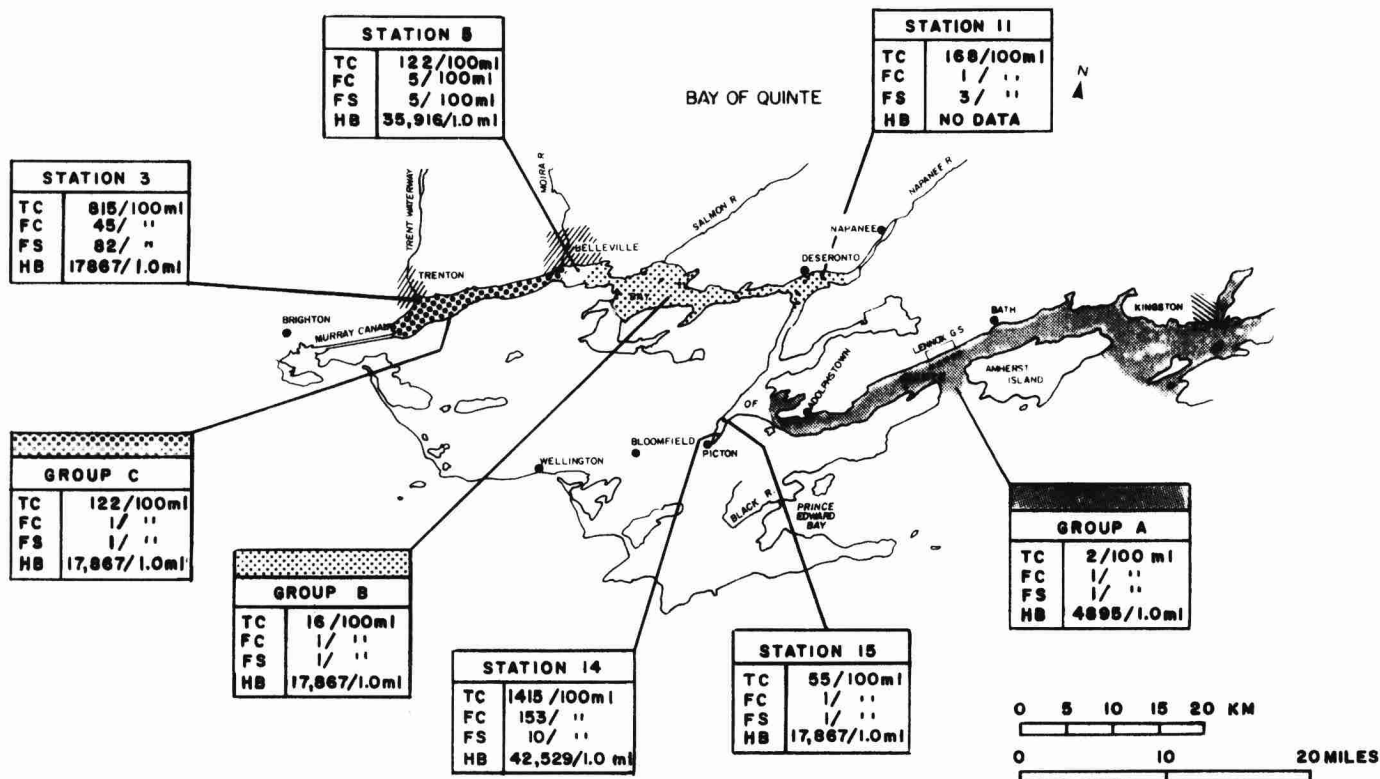


FIGURE 2 BAY OF QUINTE, APRIL 1974.

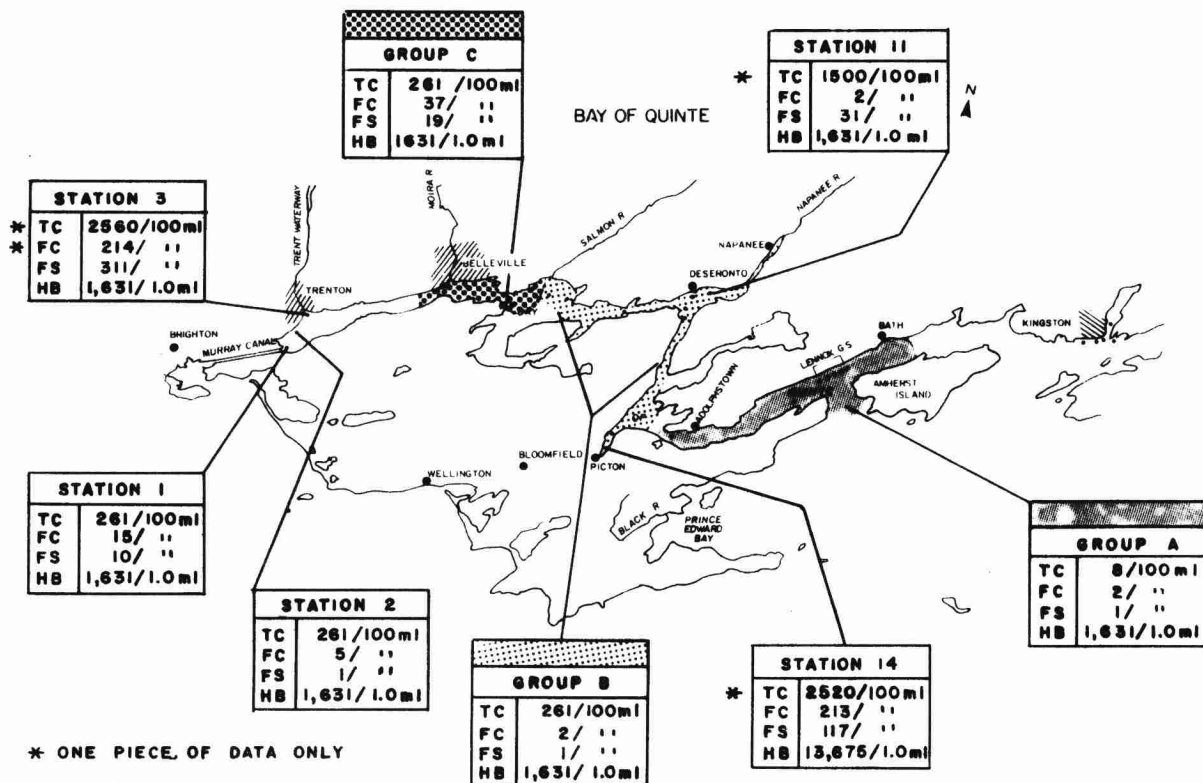


FIGURE 3 BAY OF QUINTE, MAY 1974.

HB concentrations had decreased between April and May and were at 1630/ml over the entire area except at Picton (13,675/ml).

The outer bay which opens into Lake Ontario once again had the best water quality in the area.

Water quality in June (Figure 4) had improved over the previous two months. Elevated bacterial levels were again found at Trenton (Station 3 : 480 TC, 100 FC and 102 FS/100 ml), Belleville (Station 5 : 15 FC and 5 FS/100 ml) and Picton (Station 14 : 80 TC, 14 FC and 12 FS/100 ml) and also near Deseronto (Station 10: 161 TC and 15 FC/100 ml). The FC:FS ratios near Belleville and Deseronto suggest a pollution of human origin.

The entire survey area had a HB concentration of 263/ml except at Trenton where levels were extremely high (106,000/ml).

In July (Figure 5), TC densities were significantly higher than in June particularly at Trenton (Station 3 : 5190/100 ml) and Picton (Station 14 : 1590/100 ml) where levels exceeded MOE Recreational Use Criteria.

The FC:FS ratio at Trenton suggests pollution from a human source.

The TC concentration at the mouth of the Napanee River (Group B: 701/100 ml) was also quite high as was the FC:FS ratio. The outer bay (Group A) which had previously had from 2-8 TC/100 ml had deteriorated and had TC levels of 104/100 ml.

Further deterioration of the inner and middle bays was noted in August (Figure 6) with TC concentrations of 6,210/100 ml. These levels were considerably higher than those of any of the previous surveys. However, FC and FS levels had shown little change from July except at Trenton where levels of FC exceeded 600/100 ml indicating a major pollution source of human origin.

The water quality of the outer bay did not change significantly from July.

The cause of increased TC concentrations in the survey area during July and August and the particularly bad deterioration of water quality at Picton

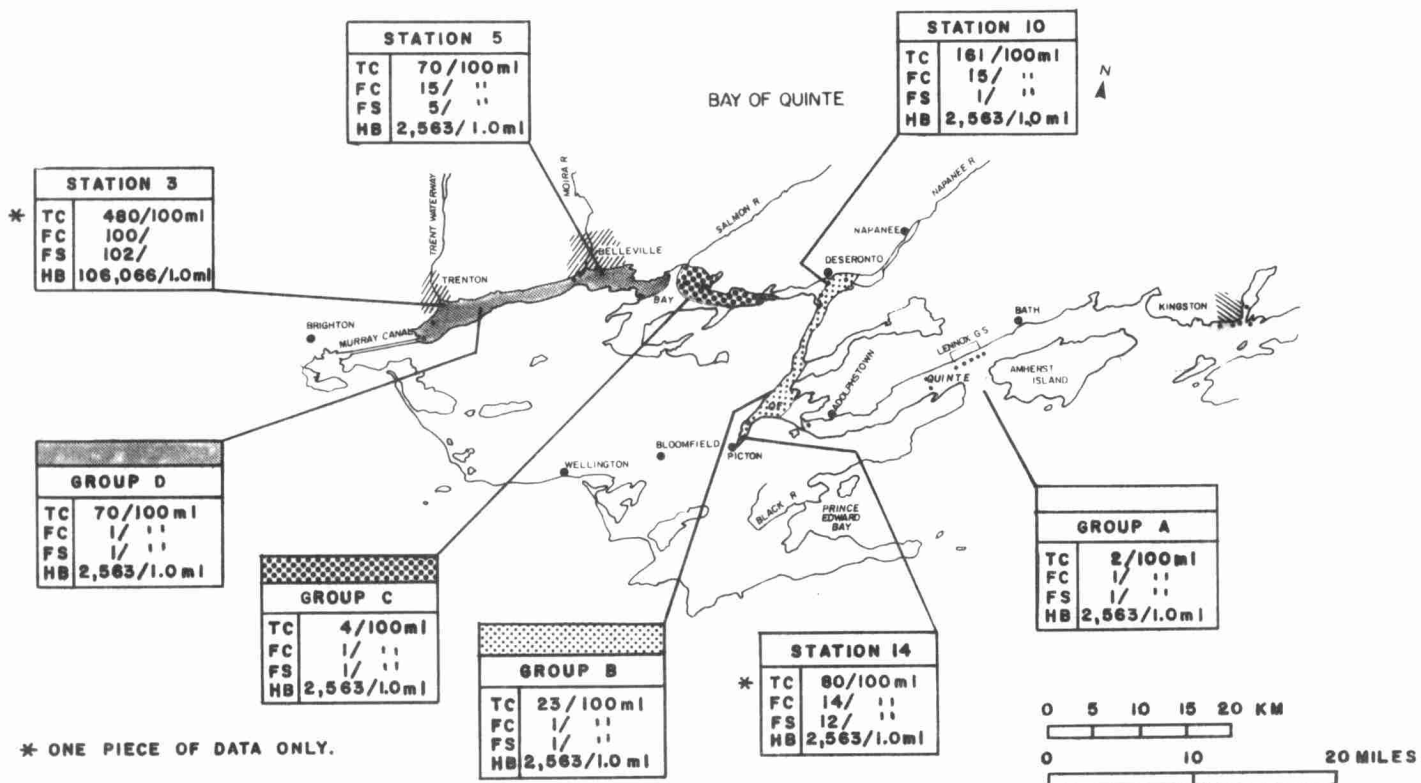


FIGURE 4 BAY OF QUINTE, JUNE 1974.

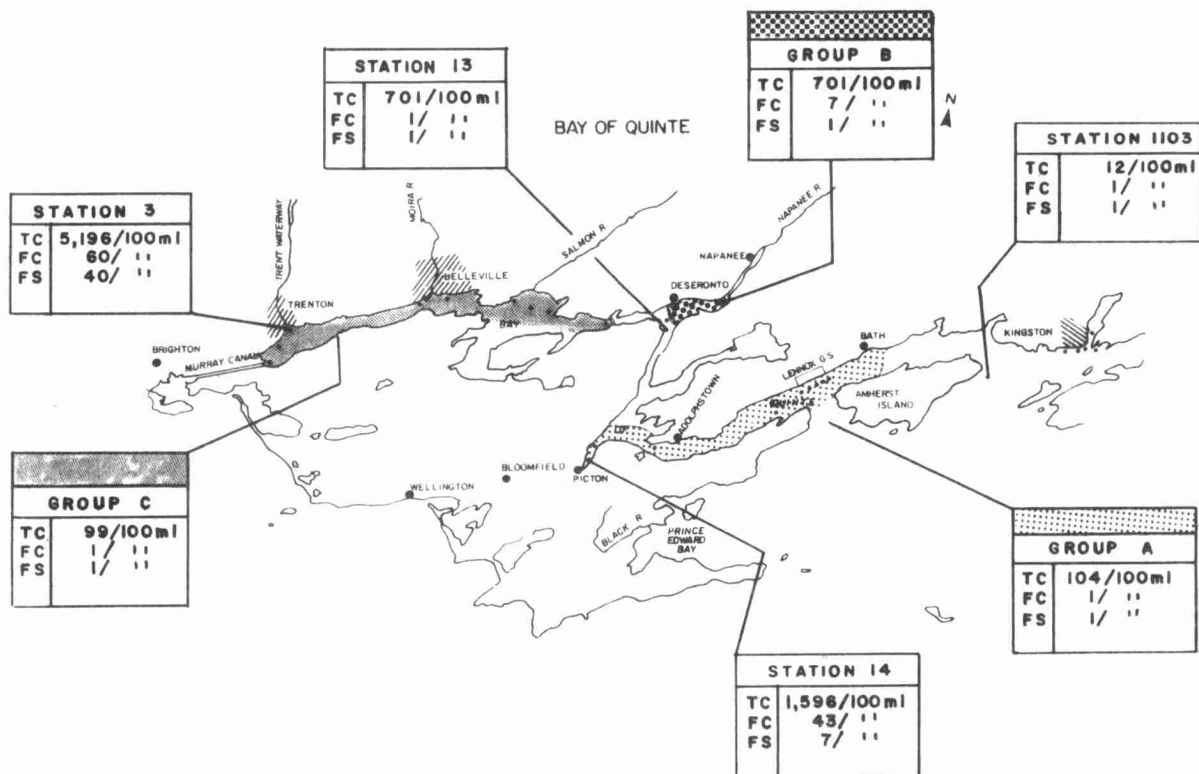


FIGURE 5 BAY OF QUINTE, JULY 1974.

and Trenton may be from increased loadings due to the greater population in the area during the summer recreational period.

Increased water temperature may also contribute to increased concentrations of some heterotrophic bacteria (e.g. Aeromonads).

During September (Figure 7) bacterial levels at Trenton continued to be very high and exceed MOE Recreational Use Criteria (Station 3: 31,000 TC, 600 FC and 83 FS/100 ml). The FC:FS ratio remained well above 4 indicating the major source of pollution was probably improperly treated human fecal material. TC densities were also somewhat higher than the remainder of the bay at Belleville (Station 5: 227/100 ml) and Deseronto (Station 10: 171/100 ml). The outer bay once again had very good water quality.

The HB levels were once again high through most of the survey area (11,080/ml) particularly at Trenton (Station 3: 857,321/ml).

The results of the 1974 surveys indicated that the Bay of Quinte received bacterial inputs from a number of sources. The areas which appear to be major contributors of bacteria to the bay are Trenton (Trent River), Belleville (Moirs River), Napanee River-Deseronto and Picton. The levels of bacteria determined at these locations during the 1974 surveys are listed in Table 1. In the majority of cases the FC and FS densities tend to indicate inputs from combined human and non-human sources. Non-human sources appeared to be a major factor at Trenton and the Napanee River-Deseronto area in April and May.

A human source, probably improperly treated fecal material, was indicated in April at Picton, in June at Napanee and in August and September at Trenton.

The worst water quality was found at Trenton where one or more of the sanitary indicator bacteria approached or exceeded MOE Recreational Use Criteria. Picton would have to be considered as the area with the second worst bacterial water quality.

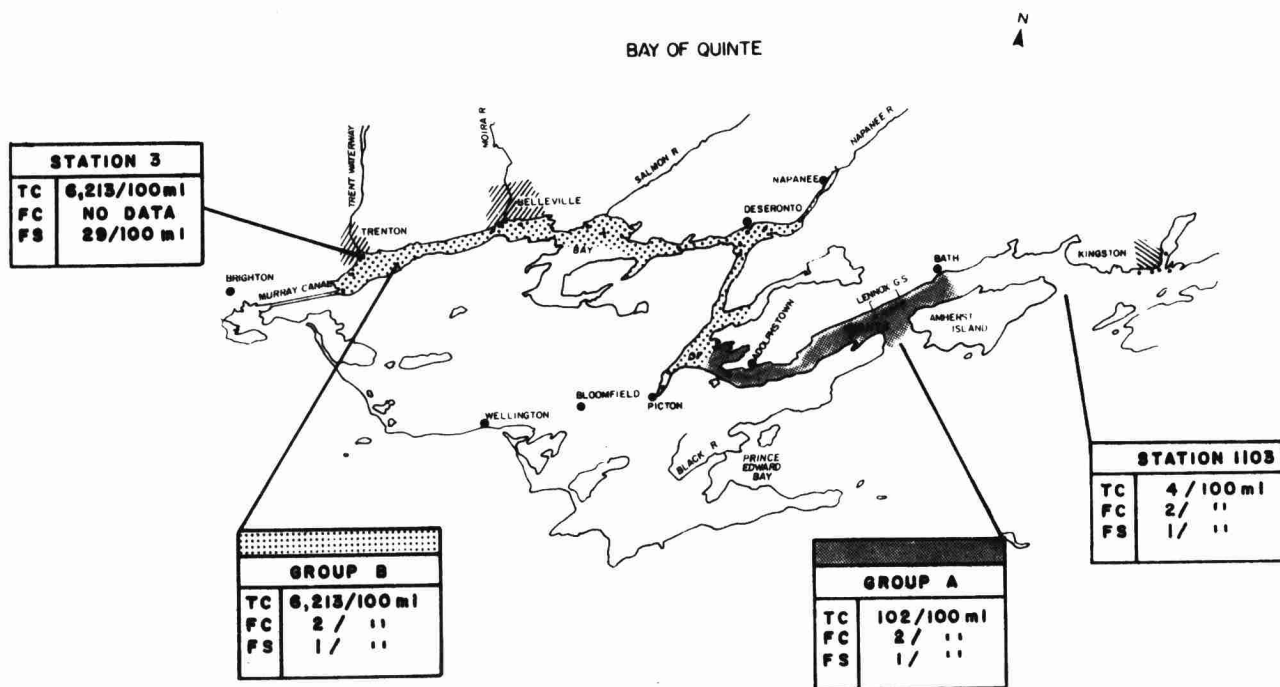


FIGURE 6 BAY OF QUINTE, AUGUST 1974.

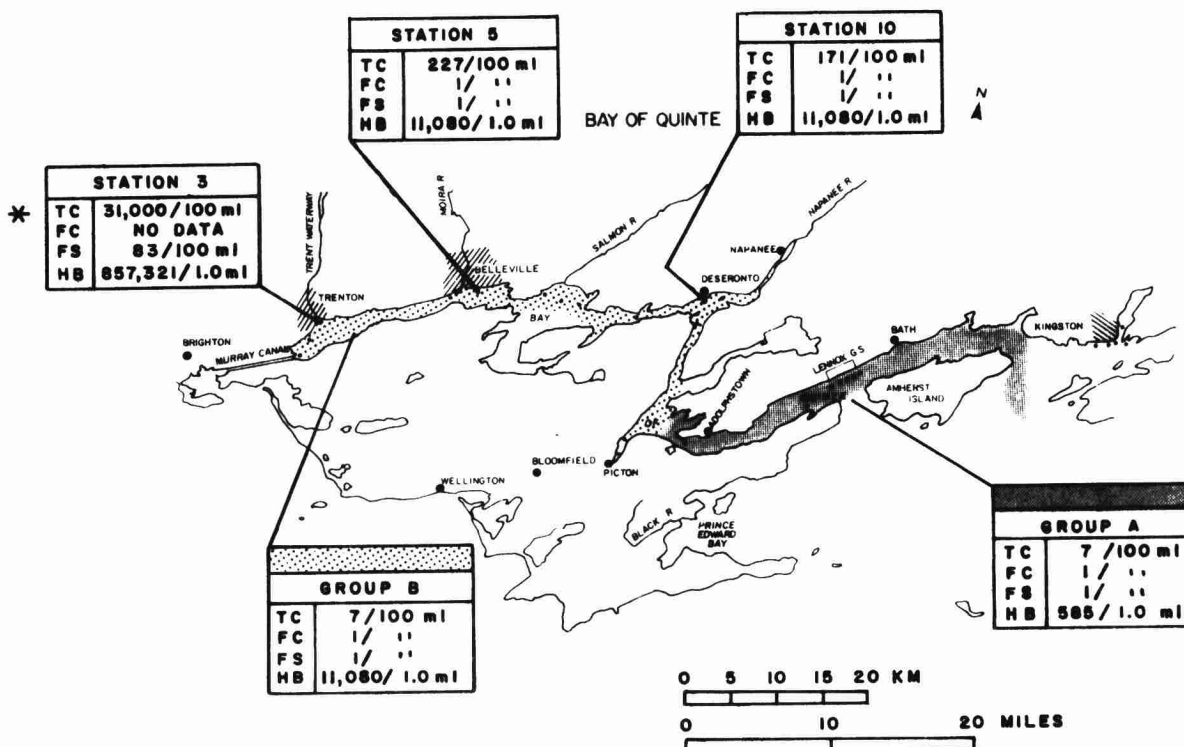


FIGURE 7 BAY OF QUINTE, SEPTEMBER 1974.

TABLE I

Trenton (Station 3)

<u>Month</u>	<u>TC</u>	<u>FC</u>	<u>FS</u>	<u>HB</u>
April	815	45	82	17,900
May	2,560	214	311	1,630
June	480	100	102	106,000
July	5,200	60	40	-
August	6,210	> 600	29	-
September	31,000	> 600	83	857,000

Belleville (Station 5)

April	122	5	5	35,900
May	261	37	19	1,630
June	70	15	5	2,560
July	99	1	1	-
August	6,210	2	1	-
September	227	1	1	11,000

Napanee River-Desoronto (Station 10 and 11)

April	168	1	3	-
May	1,500	2	31	1,630
June	161	15	1	2,560
July (Group B)	701	7	1	-
August	6,210	2	1	-
September	171	1	1	-

Picton (Station 14)

April	1,420	153	10	42,600
May	2,520	213	117	13,700
June	80	14	12	2,560
July	1,600	43	7	-
August	6,210	2	1	-
September	7	1	1	11,000

The remaining two areas (Belleville and Napanee River-Deseronto) were not as bad but must be considered areas of concern because of occasional high bacterial levels, in fact the water quality of the entire Bay of Quinte gives causes for concern because of the high bacterial densities in July and August during a time of intensive use.

A further indication that pollution in the Bay of Quinte is a source for concern comes from a 1967 survey designed to study the incidence of Salmonella in the area (6). There were ten locations for which samplings were obtained and it is important to note that the five locations from which Salmonella were isolated were located at Trenton, Belleville and Picton.

SUMMARY

The bacterial water quality of most of the Bay of Quinte was reasonably good during the months of April, May, June and September particularly in the outer bay area. Water quality showed signs of deterioration in July and excessive TC concentrations were present during August over the entire area except the outer bay. HB levels indicated that nutrient levels in the Bay of Quinte were higher than in non-polluted areas such as the nearshore of Lake Huron (7).

Four areas which at times had bacterial concentrations higher than surrounding waters were located by Picton, Trenton, Belleville and Napanee River-Deseronto area. Further work is required to determine the input sources in the above areas, particularly at Picton and Trenton, so that necessary corrective measures may be assessed.

Improving water quality in this area is important because of the heavy usage it gets during the summer period by cottagers and tourists.

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APPENDIX

Foot and Taylor Agar (modified)

Peptone	3.0 g
K_2HPO_4	0.2 g
$MgSO_4$	0.05 g
$FeCl_3$	0.2 ml of a 0.5% Solution
Soluble Casein	0.5 g
Agar	20 g
DH_2O	1000 ml
pH 7.2	Autoclave 15 min/15 psi

BACTERIOLOGICAL WATER QUALITY
OF THE ST. LAWRENCE RIVER (MAITLAND AREA)
JULY 23-28, 1975

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Abstract

The results from the July 23-28, 1975 St. Lawrence River survey indicate Sanitary Indicator Bacteria levels to be well below the Ministry of the Environment Recreational Use Criteria. However, elevated Heterotrophic Bacterial and Pseudomonas aeruginosa levels between Little Church Bay and Dupont Chemicals close to the Canadian shoreline indicated nutrient enriched waters and the possibility of a public health hazard in the area.

Objectives:

The survey from Maitland to Cornwall on the St. Lawrence River from July 23-28/75 was done with the objectives of:

- 1) Assessing the existing water quality in terms of compliance with Ministry criteria and IJC objectives.
- 2) Assessing the cause(s) of any violation of these permissible or desired levels.
- 3) Assessing the material input to the river from specific pollution related sources.
- 4) Assisting in the recommendation of abatement measures as necessary for water use.

Methods:

a) Field.

The sampling area comprised 11 river ranges from Maitland to Cornwall (Fig.1). Samples were taken at five points on each river range for six consecutive days from the American to Canadian shoreline. (Table 1). All samples were collected in 175ml sterile glass bottles and stored on ice until they arrived at the mobile laboratory at Brockville within 12 hours of sampling.

b) Laboratory

All samples were analyzed for total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) within 24 hours of sampling and counts were recorded as the number of organisms per 100 ml.

Analyses, using the Membrane Filtration (MF) technique, were done according to Standard Methods (13th Edn.) (1) using M-Endo Agar Les (Difco) for TC, MacConkey Membrane Broth (Oxoid) for FC and M-Enterococcus Agar (Difco) for FS determinations. Analyses were also carried out to determine heterotrophic bacteria (HB) and Pseudomonas aeruginosa (P.aer.) levels. The HB determination was done within 12 hours of sampling and P.aer within 24 hours. HB populations were determined using a spot technique (2) on modified Foot and Taylor Agar (appendix I) at 20 °C for 7 days and counts were recorded as the number of organisms per ml. P. aer densities were determined by the MF method of Levin and Cabelli (3) with incubation at 41.5 °C for 48 hours.

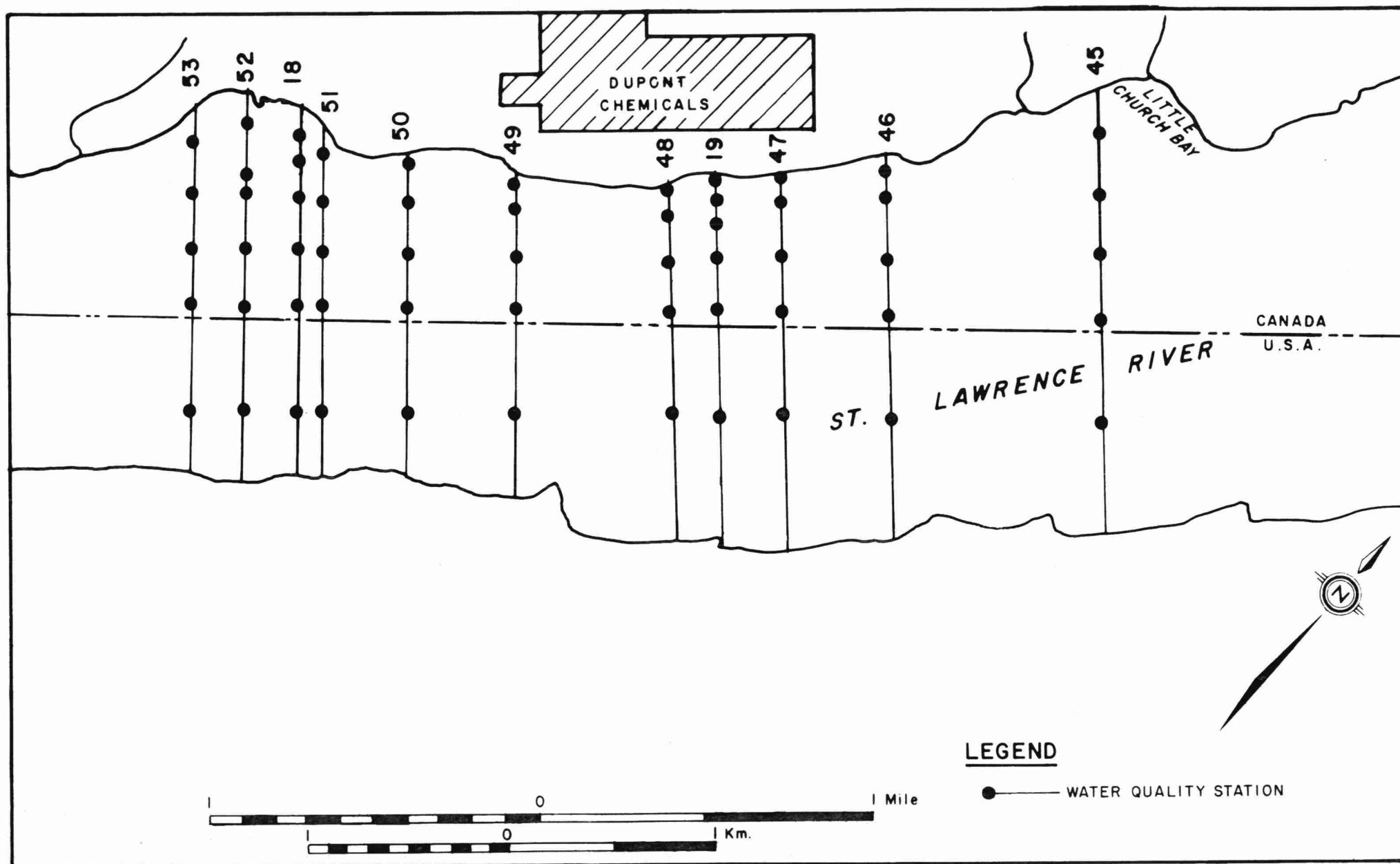


FIGURE 1: MAITLAND STUDY, ST. LAWRENCE RIVER, JULY 23-28, 1975 - BACTERIOLOGICAL SAMPLING RANGES

c) Statistical

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean (GM). Statistical methods were used to summarize the results concisely and to reduce bias in the interpretation of the data. An analysis of variance programme (ANOVA) was used to group the stations into areas within the same statistical bacterial level once the station group statistics had been obtained. In this programme the calculated F ratio must be less than the critical F ratio (0.05 level) in order that stations be accepted as a statistically similar group. At the same time the ANOVA analyses were performed, the homogeneity of the variance was also checked using Bartlett's Chi-square test of homogeneity. If either the F or Chi-square values were significant, then certain stations were withdrawn until there was no significant difference among the remaining stations. This procedure was repeated on the withdrawn stations until all possible groups were formed.

Criteria

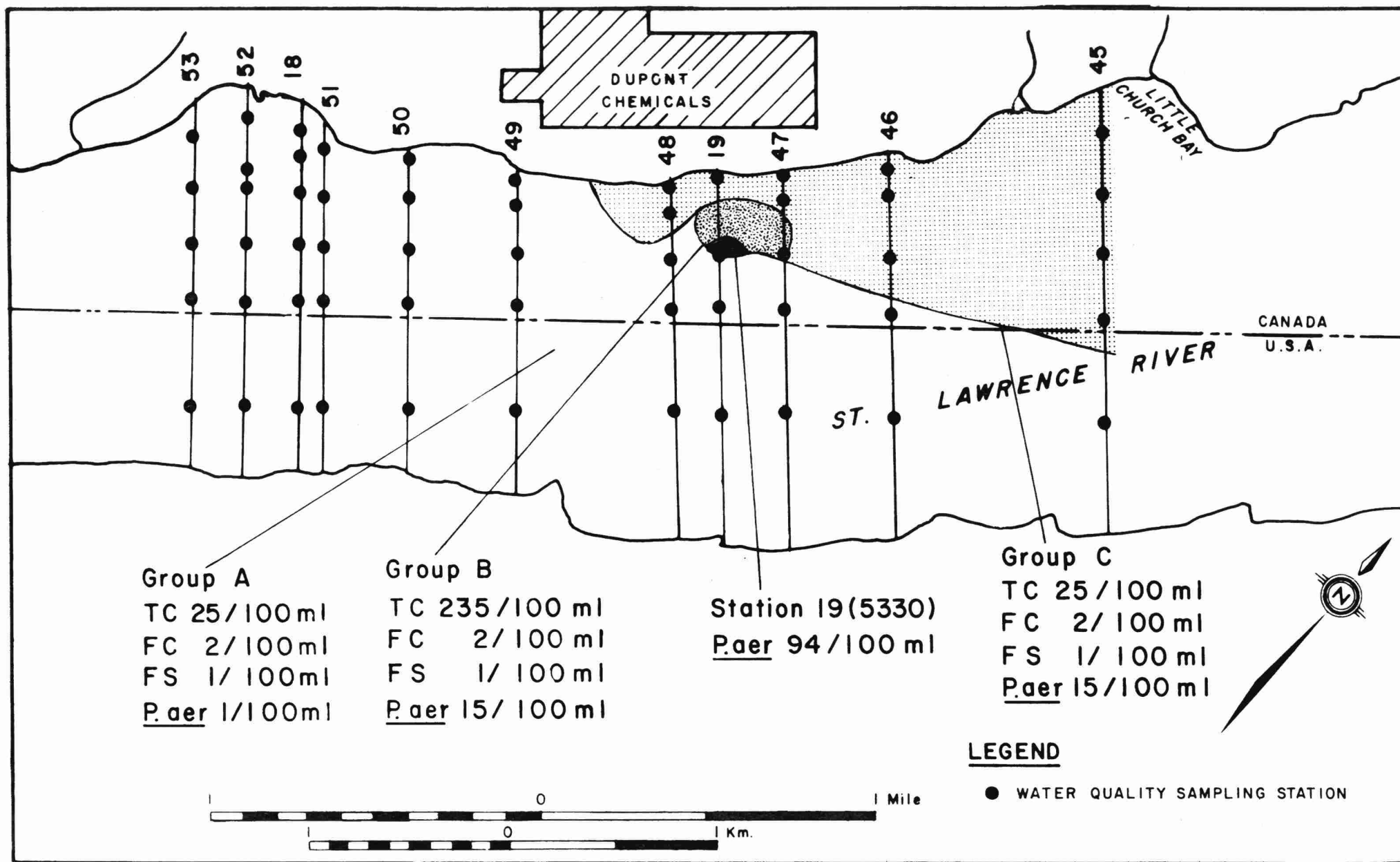
The criteria considered permissible for public surface water supplies with full treatment for the three sanitary indicator bacteria (TC, FC, & FS), and for heterotrophic bacteria are a maximum geometric mean of 5000 TC, 500 FC, 50 FS and 100,000 HB per 100 ml respectively. The maximum permissible levels of TC, FC, FS and HB for private water supplies requiring chlorination and filtration are 400, 40, 4 and 4000 per 100 ml respectively while that for waters requiring chlorination only are 100, 10, 1 and 1000 per 100 ml respectively.

The Recreational Use Criteria states that: "Where ingestion is probable, recreational water can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively..."

(4). The geometric mean of the FS results is mainly used in a ratio with the corresponding FC geometric mean (FC/FS) to gain information on the type (human or non-human) of pollution within area adjacent to, or at an input. If this ratio is greater than 4.0, the source of bacterial contamination is likely of human origin. If the ratio is less than 0.7 then the source is most likely non-human (5). It should be noted that this ratio is used to determine the type of pollution and not the safety of the water as animals can harbour human pathogens.

Results and Discussion

The water quality, with respect to the Sanitary Indicator Bacteria, was generally good on the St. Lawrence River from Maitland to Cornwall during the survey period (July 23-28, 1975). Most of the areas sampled (Map 1, Group A) had 25 TC, 2 FC, and 1 FS/100 ml except for the area around, and just east of Dupont (Ranges 19-47) which had elevated TC levels of 235/100 ml (Group B). Although these levels are below the MOE Recreational Use and Private Water Supplies (requiring chlorination and filtration) Criteria, it must be noted that the possibility of a public health hazard exist(ed) in the area between ranges 45 and 49 towards the Canadian side of the river because of high concentrations of Pseudomonas aeruginosa found there (Map 1, GRPC: P.aer. 15/100 ml). Higher levels of 94 P.aer./100 ml occurred on the Canadian side near the Dupont company (Map 1, Stn. 19-5330). The remaining sampled areas had 1 P.aer./100 ml (Map 1, GRP. A). Although no criteria has yet been established for this parameter, its presence in water could



MAP 1 : MAITLAND STUDY, ST. LAWRENCE RIVER, JULY 23-28, 1975 - DISTRIBUTION OF TC, FC, FS, AND P.aer

constitute a major health hazard since it is indicative of a local or recent source of fecal pollution of serious concern to users of waters for consumption or recreational purposes.

Dupont to Little Church Bay:

The Canadian side of the river just south -west of (ranges 48 to 45) had heterotrophic bacterial (HB) densities ranging from 225,000 (Map 2, GRP B)-325,000/ml (Stn.45- 6310) while the remaining areas had a HB density of 8320/ml. (Map 2, GRP A).

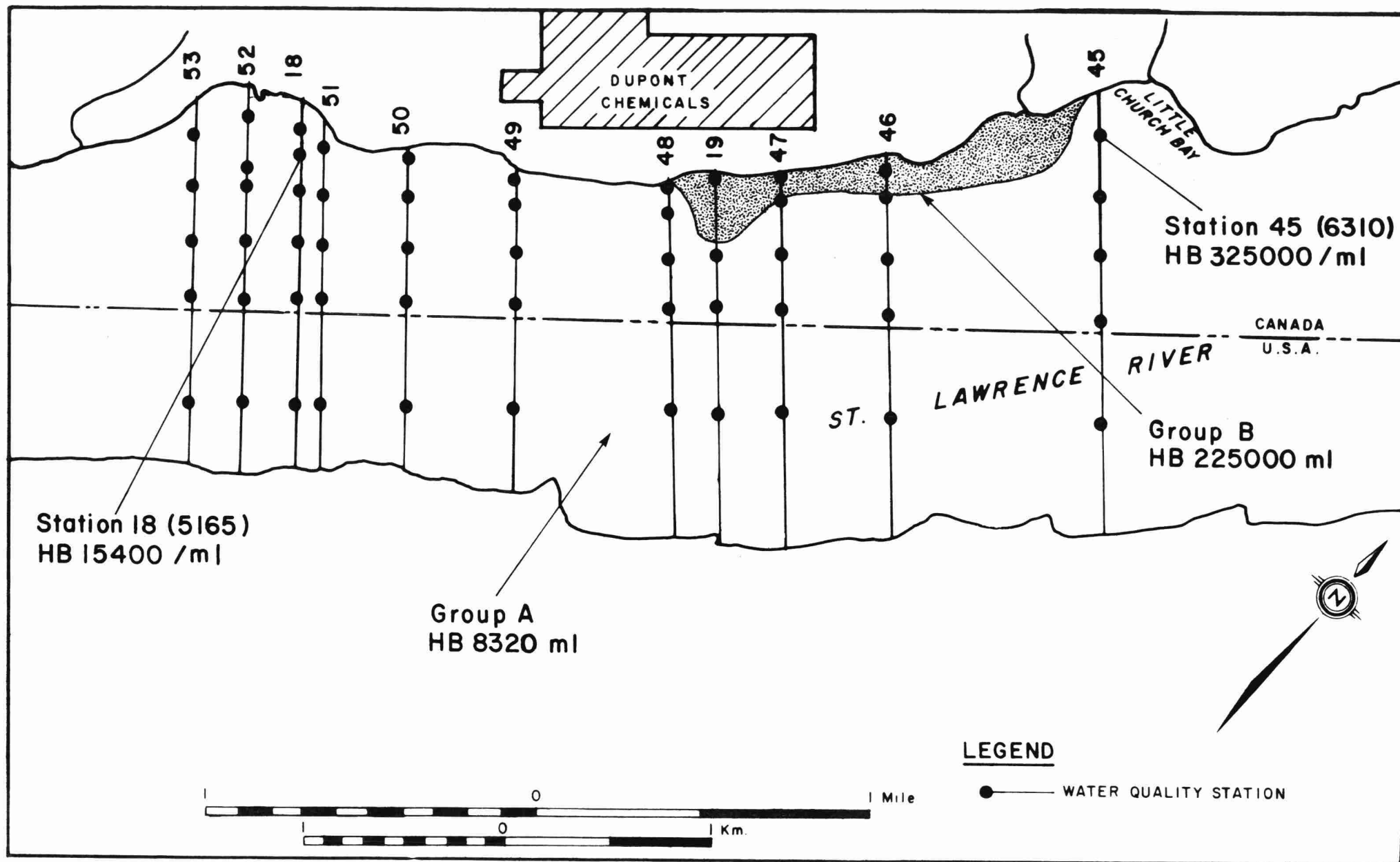
These levels may reflect a higher degree of nutrient enrichment between ranges 48 and 45 toward the Canadian side or heavy inputs.

Summary and Conclusions

Sanitary Indicator Bacterial levels were below the MOE Recreational Use and Private Water Supplies (requiring chlorination and filtration) Criteria. The possibility of a public health hazard exist(ed) especially between ranges 45 and 48 closer to the Canadian shoreline because of higher Pseudomonas aeruginosa densities in the area. HB levels exceeded the Public and Private Water Supplies Criteria and could be indicative nutrient enriched waters.

Only one bacteriological survey was carried out in 1975. If trends are to be established, more surveys should be carried out in any given year to better establish areas of input and influence of the various sources of pollution.

Areas below current MOE Criteria should not be regarded as unpolluted since transboundary movement of water currents and the flushing action of the river can redistribute contaminants and bacteria from hazardous areas to areas of better water quality.



MAP 2 : MAITLAND STUDY, ST. LAWRENCE RIVER, JULY 23-28, 1975 — DISTRIBUTION OF HETEROTROPHIC BACTERIA.

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APPENDIX IFoot and Taylor Agar (Modified)

Peptone	0.5 g
K_2HPO_4	0.2 g
$MgSO_4$	0.5 g
$FeCl_3$	0.2 ml of a 0.5% Sol ⁿ
Soluble Casein	0.5 g
Agar	20.0 g
DH_2O	1000 ml
Actidione	100 ppm

TABLE I

St. LAWRENCE RIVER - RANGES SAMPLED IN 1975.

<u>RANGE</u>	<u>DISTANCE (FT.) FROM U.S. SHORE</u>				
45	1720,	3360,	4430,	5330,	6310
46	1885,	3530,	4430,	5330,	5740
47	2215,	3770,	5490,	5495,	5820
19	2050,	3690,	4510,	5330,	5660
48	1970,	3525,	4265,	5000,	5410
49	1395,	2950,	3770,	4590,	4920
50	1065,	2790,	3525,	4820,	4920
51	985,	2625,	3445,	4180,	4920
18	980,	2620,	3520,	4260,	5165
52	1150,	2790,	3690,	4510,	5495
53	1150,	2790,	3600,	4430,	5250

